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The Chesapeake and Delaware Canal.

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Mr. President and Members of the Institute:

The Franklin Institute as well as the various trade and commercial bodies of this city and of the nation have, for many years been importuning the General Government to extend the facilities for our internal commerce, over the waterways of the country, with but slight results. Other and far more potent influences have dominated legislation and retarded or prevented the passage of enabling acts to open, enlarge or emancipate our canal systems. A crisis has been reached and a return to the waterway is compulsory, because of its greater capacity and economy.

EARLY CANALS.

Three years after the inauguration of President Washington the first canal was built in the State of Massachusetts, at South Hadley, around the falls of the Connecticut River, which were fifty feet in height. It was two miles long, had five locks and passed through a cut forty feet in depth.

Among the earliest charters granted was that of the Dismal Swamp Canal, in Virginia, which was designed to be only 32 feet wide, and to float vessels of 3 feet draught, for the purpose of getting timber from the swamp. In 1816 the company was authorized to raise $50,000 by lottery to enlarge the locks, which were 90x32x4 feet in dimensions.

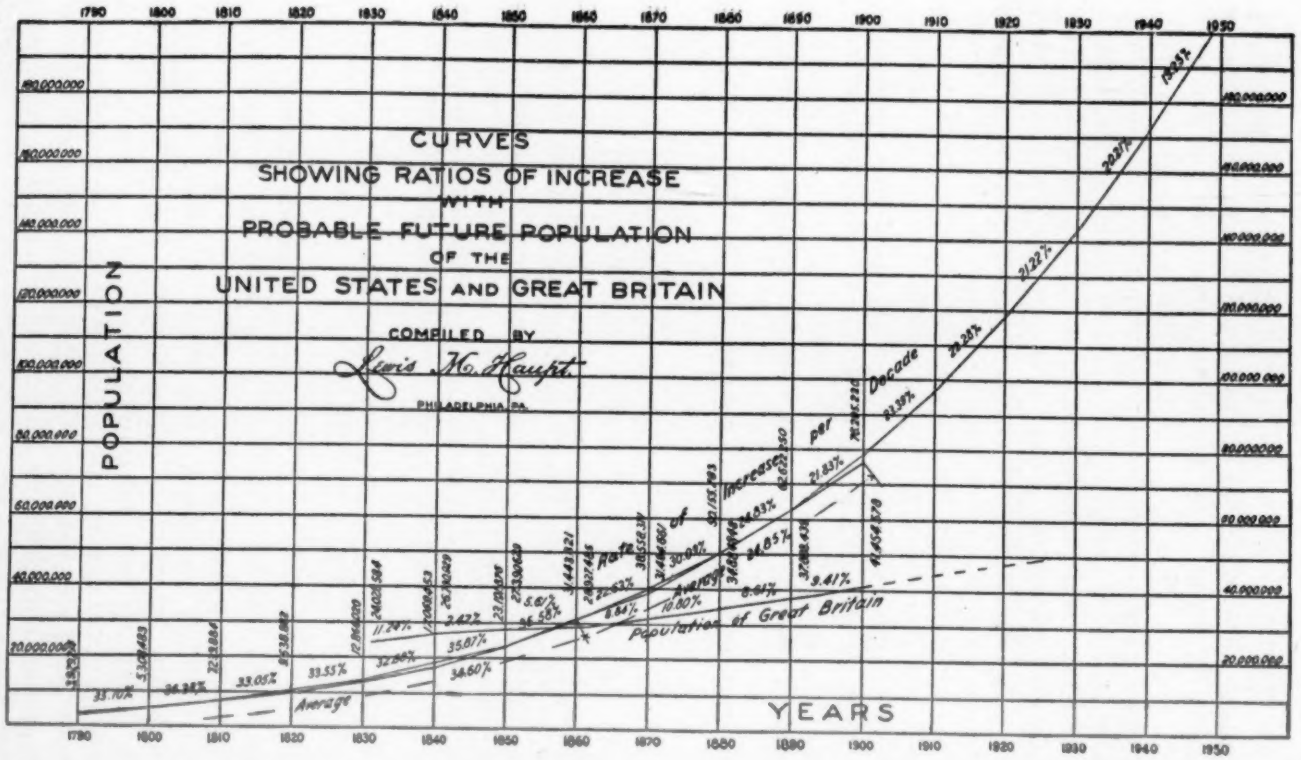
Similar recourse was authorized by the State of Pennsylvania to complete the work on the Union Canal, which was designed to connect Lake Erie with Tidewater, and after having contributed $300,000 to the company the State, in 1821, guaranteed the interest and granted a monopoly of lotteries.

Thus sustained, work was resumed in 1821, and the link between the Susquehanna and the Schuylkill Rivers was completed in 1827, or 37 after its beginning and 65 years after the first survey.

These few facts are submitted to illustrate the difficulties encountered at the beginning of the canal epoch, when there were no avenues of communication save a few earth roads and the natural watercourses. During these forty years (1790-1830) the population, which is the basis of internal communications, increased from about 4,000,000 to nearly 13,000,000 and the canal mileage at the end of 1834 was reported to be 2617.89 miles.

CHEAP FUEL THE ISSUE.

The greatest economic stimulus was given to canals by the discovery of hard coal on the Mauch Chunk (Bear) Mountain, in 1792, by one Philip Ginter, who took a sample to Col. Jacob Weiss, and he, in turn, submitted it to Michael Hillegas, the first Treasurer of the United States, as well as to John Nicholson, and Chas. Cist, a printer, all of Philadelphia. About the beginning of 1792 these parties formed the "Lehigh Coal-Mine Company," and took up from 8,000 to 10,000 acres of


CURVES
SHOWING RATIOS OF INCREASE
WITH
PROBABLE FUTURE POPULATION
OF THE
UNITED STATES AND GREAT BRITAIN
COMPILED BY
Lewis M. Haupt.
PHILADELPHIA, PA.
POPULATION
YEARS
Average
Population of Great Britain
Decade
1790
1800
1810
1820
1830
1840
1850
1860
1870
1880
1890
1900
1910
1920
1930
1940
1950

lands, but the difficulties of securing transportation compelled them to abandon their enterprise. At that time hard wood was selling in the city at $13 per cord. It was found to cost $13.50 to haul a "load" of coal by wagon from the quarry to Philadelphia, so that it could not compete profitably with hickory, and the Schuylkill and Lehigh Navigation Companies became a necessity. These canals, together with the Erie, the Chesapeake & Delaware, the Delaware & Hudson and many others were in operation by 1829.

THE RAILROAD EPOCH.

But canals could not be built where water was not available and the rapid increase and distribution of population, coupled with the invention of the locomotive gave a great impetus to the construction of railways, which have now become the dominant transportation interest in the country. From about 1,000 miles in 1835, they have expanded to 220,028.44 miles at the end of June, 1906. This is exclusive of sidings and yard trackage.

ENORMOUS POPULAR INVESTMENTS IN CORPORATE COMPANIES.

The total liabilities in bonds, stocks, &c., amount to $16,-219,573,845. The gross receipts to $2,319,760,030, which is 14% of the capital. It represents the annual tolls for freight, express, passenger and other service paid by the patrons of the system. The total expenses for maintenance and operation are $1,532,163,153, leaving 33% for the payment of interests, rents, taxes and dividends, so that there results an average dividend on this enormous capital of only about 3.65% on bonds and 3.02% on the capital stock. Some roads pay nothing. Those which pay the best are located along the watercourses where there is the cheapest kind of competition. Hence the development of waterways cannot injure the shareholders of railroad securities.

During the past year after paying 590 millions for betterments and 230 millions for dividends, the railroads had a credit balance of $100,428,707.

DIAGRAM SHOWING TOTAL MILEAGE
OF THE
RAIL ROADS of the UNITED STATES
Built mainly from popular subscriptions under Corporations.
Total mileage June 30, 1906, 220,028.00 miles
" capital (stock) $16,219,573,845.00
" receipts (all sources) 2,319,760,030.00 49 %
" expenses (opt & maint) 1,532,163,153.00 65 "
Net earnings " 787,596,877 33 "
" " other sources 132,614,932
Deduct inst. dividends &c 920,331,959
818,792,152
Surplus $100,428,707
Rate of Interest paid on bonded debt 3.65 %
" " " capital stock 3.92 %
Total tons of freight carried, 1,435,321,748.
Average length of haul 130.45 miles
Average charge per ton-mile 0.784 cents.
" " per ton moved $ 1.02
Total freight bill paid for rail transportation per annum in the U.S. $ 1,469,518,157.
Foreign Railroad Rates per ton-mile
Great Britain 2.80 cents
Italy 2.50 "
Russia 2.40 "
France 2.20 "
Germany 1.64 "
Belgium 1.60 "
Holland 1.36 "
U.S.A. 0.78 "
220,000 mls
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
10,000 mls
0 miles
1830
1840
1850
1860
1870
1880
1890
1900
Jackson D
Van Buren D
Harrison W
Tyler W
Polk D
Taylor W
Fillmore W
Pierce D
Buchanan D
Lincoln R
Johnson R
Grant R
Hayes R
Garfield R
Arthur R
Cleveland D
Harrison R
Cleveland D
McKinley R
Roosevelt R
Civil War
8 yrs
10
11.5 yrs
L.W.H. 1906.

The total number of tons carried was 1,435,321,748,* and the average haul was only 130.45 miles. The average charge per ton-mile was 0.784 cents. This makes the average charge for each ton moved on the railroad $1.02. This enormously potent system exists by virtue of the confidence which the people of the United States, aided also by foreign capital, have placed in the integrity of the masters of transportation, who have gradually consolidated the individual and disjointed enterprises into great trunk lines stretching across the continent.

Some of these lines were subsidized by the grants of extensive tracts of land or by loans from the public treasury, but the Government has entrusted their management and operation to the corporations who have developed or purchased the control, excepting in case of war, when some of them were seized temporarily for strategic purposes. That the policy of thus encouraging local, private and corporate initiative was wise, the results have amply proven.

It cannot be claimed that the low rates on American railroads are in consequence of improved water competition, since there is practically none, with the exception of the Great Lakes, where, although the rates are the lowest, the railroads receive a much greater revenue per mile than in any other portion of the country. In group II (New York to Md. inc.) the rate is 0.667 cents and the receipts from freight per mile is $14,010, which is nearly double that of New England (I) and three times that of group IV.

On the other hand, the European railways, where there are well developed competing waterways, are enabled to charge from three to four times as much for an equivalent service. Thus in Great Britain the average charge is 2.2 cents; in Italy, 2.5; in Russia, it is 2.2; in France, 2.2; Germany, 1.64; Belgium, 1.60, and in Holland, 1.58, while at home it is only 0.78.

CONGESTION.

The curve of progress, in this matter of overland transportation, indicates that the end is not yet, but the experience of the past year serves to emphasize the fact that the railroads

*5150 square miles, one foot deep, when reduced to the shipping ton, or enough to blanket the entire State of Connecticut.

have limitations and that they are unable to handle the traffic in small units, especially where large quantities of low grade freights are required to keep the wheels of industry in motion, or even to provide the requisite amount of food and fuel to the populous centers.

That a crisis has been reached due to the failure of the carriers to handle the products of the soil and their inability to secure the necessary terminal facilities will be apparent from a few extracts taken from the daily press, as follows:—

"Orders have been issued by the N. Y. Central Lines west of Buffalo, instructing all agents to cease soliciting business, as the roads are unable to handle what comes to them naturally, but to spend their time in hunting up cars. * * * Never in the history of Western roads was the freight congestion so great as now. It was reported that the Northern Pacific road has at least 10,000 cars which it is unable to move."

In Pittsburg the shortage of cars was recently reported to be 5000. Bradstreet says: "The really serious cause of complaint is the practically country-wide congestion in railway traffic which affects grain movement, collections and retail sales in the Northwest, delays delivery of badly needed coal supplies in the entire West, interferes with the movement of cotton to market in the South and hampers manufacturing operations in the iron and steel, textile, lumber and other trades.

An official of the Pennsylvania Railroad said: "It is almost impossible to say what car shortage exists on account of the daily increase in the amount of traffic. The demand for more cars comes from every part of our system. The general belief is that the business will increase during the next year."

In the meantime the Interstate Commerce Commission is investigating the alleged car shortage and it is reported by Commissioner Lane that the agents in the Northwest state that the roads in the wheat belt are discriminating against grain and accepting other traffic. " * * * There are millions of tons of freight awaiting shipment at the present time, which the railroads confess themselves unable properly to handle. Whether there is an actual car shortage or not is a question to be determined, but that there is fault to be found with the manner in which cars are used seems to be generally conceded by all traffic men."

Later dispatches, dated from North Dakota, Dec. 16, report that "A frightful condition exists owing to scarcity of fuel. Several persons have frozen to death as a result of the railroads inability to furnish cars for the shipment of coal and wood. Two entire families perished. In scores of places no coal can be bought. Farmers are making no efforts to ship their wheat, which is left lying under the snow; the cry is for

fuel. Hay and straw are being burned, as well as fences and outbuildings, even the grain in the elevators is threatened, while the railroads and common roads are blocked with snow."

Dec. 17.—Nebraska towns are out of fuel and the price has risen to $18 and $20 a ton. In Western Kentucky there is a coal famine, and oil is scarce in Phoenix, Arizona, so that the electric and gas companies have been shut down.

The Interstate Railroad Commission is startled at the reports which are coming in from the West.

To meet this condition some roads are placing millions of dollars in additional rolling stock, and heavier locomotives, but after all, it comes back to the inadequate facilities for unloading these units at the terminals. President Hill, of the Great Northern Railroad, has very truly said that "To-day the entire country is suffering from want of transportation facilities to move its business without unreasonable delay. The prevailing idea with the public is that the railways are short of cars, while the facts are that the shortage is in the tracks and terminals to provide a greater opportunity for the movement of the cars."

Hence to increase cars without a corresponding increase in yards and storage capacity, merely aggravates the evil and increases the cost. In fact, a recent report of one of our trunk lines stated that its operating expenses had been increased 25% in the year because of the lack of facilities, and the difficulty of securing them is rapidly increasing. It is admitted that suitable terminals cannot be had in the vicinity of New York harbor to-day for $150,000,000.

COLD AND FAMINE.

Thus while our surplus food supplies are bottled up on the farm, there comes a far cry from the older civilizations, of distress, poverty, and crime, terminating in death, because of the absence of food.

Twenty millions of Russians affected by famine and parents selling their *daughters* to Mohammedans for $50 for the worst kind of servitude. Children whose ages range from 12 to 17 years are thus sold for food. The "hunger typhus" fever, resulting from starvation, is epidemic in Kazan.

Fifteen millions of Chinese are reported to be suffering from flood, fever and famine.

A CHANGE OF POLICY DEMANDED.

The remedy for these economic and social problems involves a radical change of policy. The railroads have in the past absorbed many of the canals and waterways which were regarded as dangerous rivals and have undertaken to handle the crude, freights of low value, by mechanical devices, involving at least three times the cost of the water-borne traffic. They have leased canals, at high rates of interest, merely to keep the traffic on the rails and have compelled manufacturers to pay much higher rates for coal, ores, lumber and other materials.

It would seem that the time had arrived when the traffic should be segregated to the cheapest, most capacious and quickest conveyors for the bulky materials, that the higher class freights may have the right-of-way and there may be less congestion in the yards and terminals. To this end all through freights for export or coastwise delivery, should be shipped at the nearest tidewater terminals and not be hauled into the great cities at all where the miles of cars greatly add to the dangers and delays of municipal traffic.

Thus the neglected condition of our internal and coastwise waterways is being forced upon the attention of the public as a necessary aid to the traffic of the country. Although about $400,000,000 have been expended upon these works since 1822 by the Government, the projects already approved by Congress, are estimated to cost over $400,000,000 more to meet the demands of the present day, and it is now difficult to secure the passage of a River and Harbor bill, even every three years. Legislation is blocked so subtly that it is next to impossible to prevent it. Some of the most important measures for the opening of the rivers and canals of the country, even where no expense is involved, are delayed for a score or more of years. Yet the plea is made that the funds can be applied to better advantage than for internal commerce. In this great and prosperous country, committed to the policy of arbitration and deriving all its revenues from the avocations of peace, the demand arises continually for over seventy per cent. of the total appropriations for destruction and waste; while a mere bagatelle is applied to construction and economy, the administrative, judicial and legislative de-

partment. Is this good business? If not, then it is neither good policy nor good government.

THE NAVAL BUDGET.

In a recent dispatch from Washington to the press it was stated that the nation expends over $100,000,000 annually for a navy which is in a low state of efficiency and that the officers are too old, as well as the vessels, while one of the "ancient," and hence experienced, mariners in a public address, delivered not long since, admitted that the battleships were obsolete and the cruisers of little use. Another officer says that the life of the heavy guns is limited to about sixty rounds, which could be fired in an hour and a half, so that a new system of guns and of firing them is recommended. In the meantime it is reported that the situation in Japan is becoming threatening over the inability or unwillingness of this country to educate the Japanese children in the schools of the Pacific Coast, and that the Philippines and Hawaii, as well as the Pacific seaboard need to be protected by larger fleets, and the Panama Canal to be pushed rapidly to completion so as to be ready for any emergencies. Which means larger appropriations for these great floating war engines, which may be scuttled in a moment by a stray shot or uncharted rock.

There are some striking figures in the bulletin just issued from the Treasury Department for the expenses of the coming year, as follows:—

Out of a total approaching 700,000,000 dollars there is to be applied to Government expenditures (Legislative, Executive, Judicial and Foreign intercourse) nearly $40,000,000; to Miscellaneous and Permanent appropriations, $209,000,000, and to Public Works, $95,000,000. On the other hand, for the elements of war and its concomitant evils there are the items of

War	$ 79,950,102
Navy	115,444,950
Indians	7,970,160
Pension	138,243,000
Making a total of	$341,608,212

Agriculture and Internal Commerce, which are the chief

sources of the wealth and revenue, have the smallest appropriations, and they are the most uncertain and difficult to secure.

Under these conditions, therefore, it is manifest that the country cannot expect any very rapid development to result from the exercise of its jurisdiction over the waterways, and this obstructive system of governmental control and patronage stands out in glaring contrast with the enormous expansion of the less profitable rail transportation, now so generally useful, but already outgrown by the productive industries of the nation, which demand greater relief.

A MANIFEST REMEDY.

The remedy must lie in the return to the ante-bellum policy of permitting any section, State or corporation to undertake its own improvements, whenever there is an apparent need. In many instances this would have been done had it not been necessary first to secure a special act from Congress. The greatest and most beneficent canal in the world to-day as to tonnage was opposed by the Government in 1839, when the State of Michigan had provided the means to dig a canal around the falls of the Sault Ste Marie, but the United States declined to grant a right-of-way through its military reservation. This opposition of the military arm continued until 1852, when the State finally undertook the work, and subsequently, after its utility was demonstrated, conveyed it to the Government.

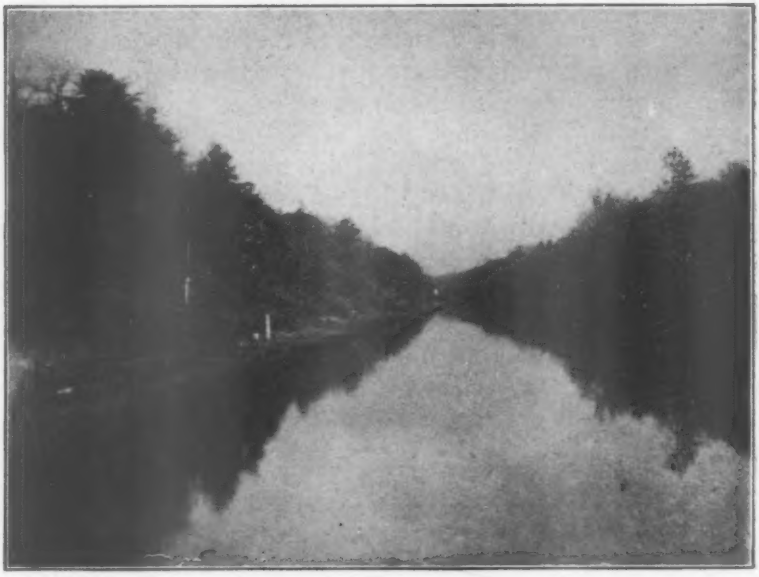
THE KEYSTONE OF THE COASTWISE SYSTEM.

Many other instances might be cited of works which have been retarded for a generation, but suffice it to refer to the case of the Chesapeake & Delaware Canal, the enlargement of which was urged by a Convention, held in Baltimore as early as 1871, when it was recommended that, "If found to be practicable, desirable and valuable to the great interest of the country, that the said ship canal be constructed."

On the 11th of March, 1872, the House of Representatives called on the Secretary of War for a report on this project, but it was not until 1878 that an appropriation was made for the surveys upon which to base an opinion. Preliminary surveys

were made in 1879, accompanied by a report covering the lower routes and requiring further examinations into those at the northern end of the Peninsula, where it was narrowest. These were made and a report submitted in 1883, recommending that a mixed commission should be appointed "to consider and to report its opinion as to which of the various routes surveyed will afford the greatest protection in case of war, and the greatest facilities to commerce."

In 1894, eleven years later, such a commission was appointed and submitted its report to the effect that "THIS BOARD DETERMINES THE MOST FEASIBLE ROUTE FOR THE CONSTRUC-



The "Deep cut," looking east (3 miles).

TION OF THE CHESAPEAKE AND DELAWARE CANAL TO BE THE BACK CREEK ROUTE, WHICH IS SUBSTANTIALLY LOCATED UPON THE LINE OF THE EXISTING CHESAPEAKE AND DELAWARE CANAL. THIS ROUTE WILL BE BEST ADAPTED FOR NATIONAL DEFENSE AND WILL GIVE THE GREATEST FACILITY TO COMMERCE." So that after twenty-three years the Memorial of the National Commercial Convention was at length answered, and the best route was determined upon, but again local in-

terests intervened to prevent further progress for a period of twelve more years, resulting in the appointment of another mixed commission to pass upon the findings of the former board as to the relative advantages of the two most northerly routes. However emphatically it may endorse the findings of its predecessors it is feared that in view of the shortness of the session (1906-7) no definite action may be taken, as the River and Harbor bill is practically completed and will carry an exceptionally large aggregate, but it is doubtful if any item on the bill would be of greater general benefit to the entire country, as a measure of peace or war, than one authorizing the immediate construction of an open, capacious and free canal across the neck of the Chesapeake and Delaware Peninsula on the best practicable route, and making an appropriation therefor.

The basis for this confident assertion will be seen from the following extracts presented by the Trades League of Philadelphia to the Chesapeake and Delaware Canal Commission (of which General Felix Agnus is the Chairman, and Major C. A. F. Flagler, U. S. A., and Lieutenant Frank Chambers, U. S. N., are members,) at a hearing held in the Bourse, on the 27th day of September, 1906, when the following argument, in part, was respectfully submitted:—

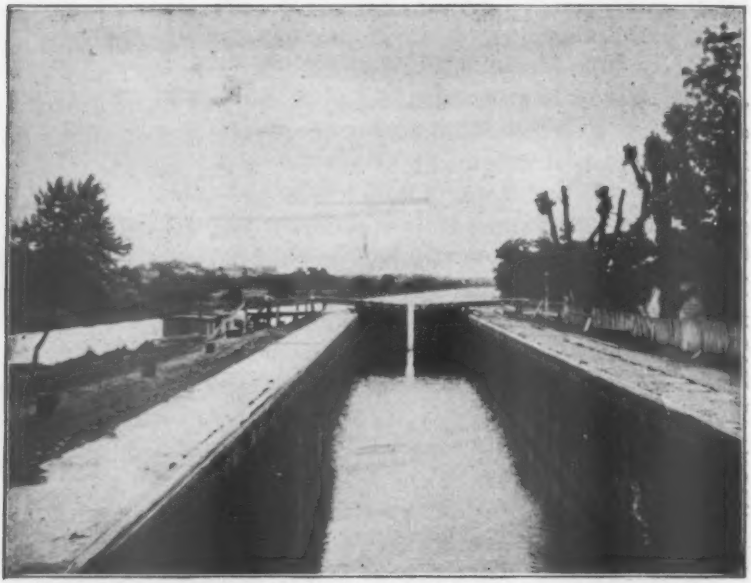
ARGUMENT OF THE TRADES LEAGUE OF PHILADELPHIA.

1. The Chesapeake and Delaware Canal is a vital factor in coast defense, which may be secured for less than the price of one battleship, while it would at least double the efficiency of an entire fleet.

2. The absence of this connection between these two arms of the sea, during the War of 1812, cost the Government its National Capital and many valuable records, worth far more than the estimated cost of the proposed enlargement, ($8,000,000).

3. The existence of the present restricted waterway, opened in 1819, saved the National Capital during the Civil War, when the overland communications were interrupted.

4. The high tariffs consequent upon its limited size, are a serious embargo upon interstate commerce, since it can pass

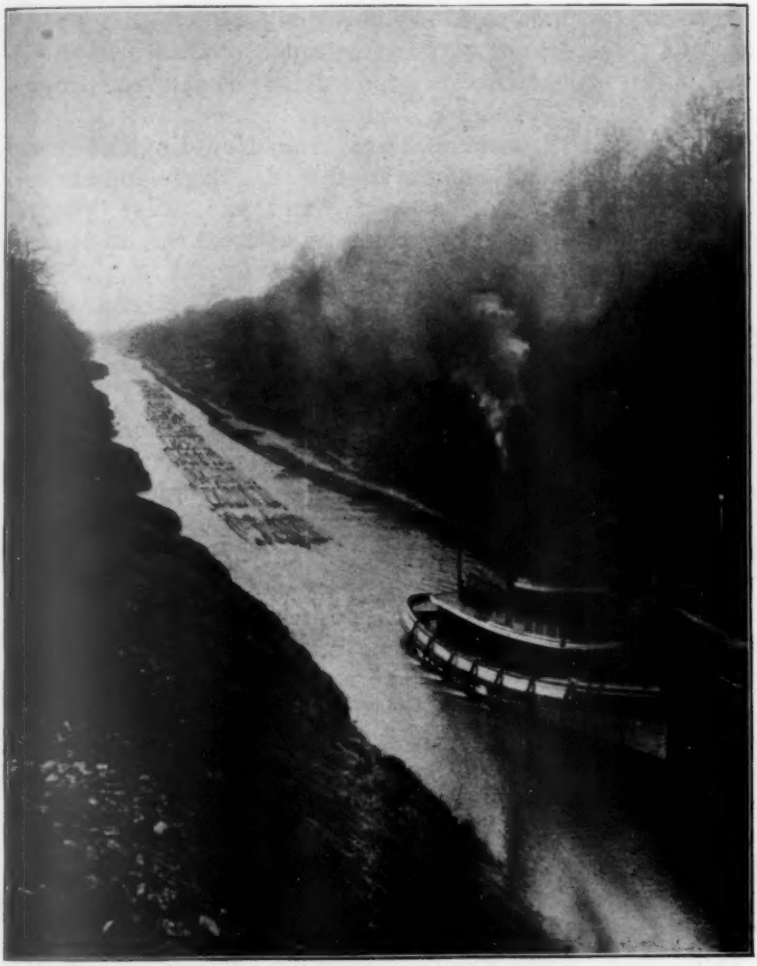


St. George's Lock (lower gates opening), only 220 feet long, 21 feet wide and 10 feet deep.

Towing lumber schooner by mule team.

barely three per cent. of the coastwise vessels, which have outgrown its antiquated dimensions.

5. The economies effected by the enlarged canal would



Towing 600-foot raft through "Deep Cut."

cover the cost of the work in a very few years, while such a canal would also operate as an efficient natural rate regulator and at the same time develop a very much larger tonnage of higher class freights for the overland carriers, thus adding

largely to their revenues. This paradoxical result has been demonstrated fully by all the great canals and cheapest waterways in the world.

6. There is a greater amount of tonnage in sight to-day (50,000,000 tons), on these two bays and their tributary waters, than now traverses any of the great canals of the world. Nearly all of this is compelled to round the capes at great expense and risk.

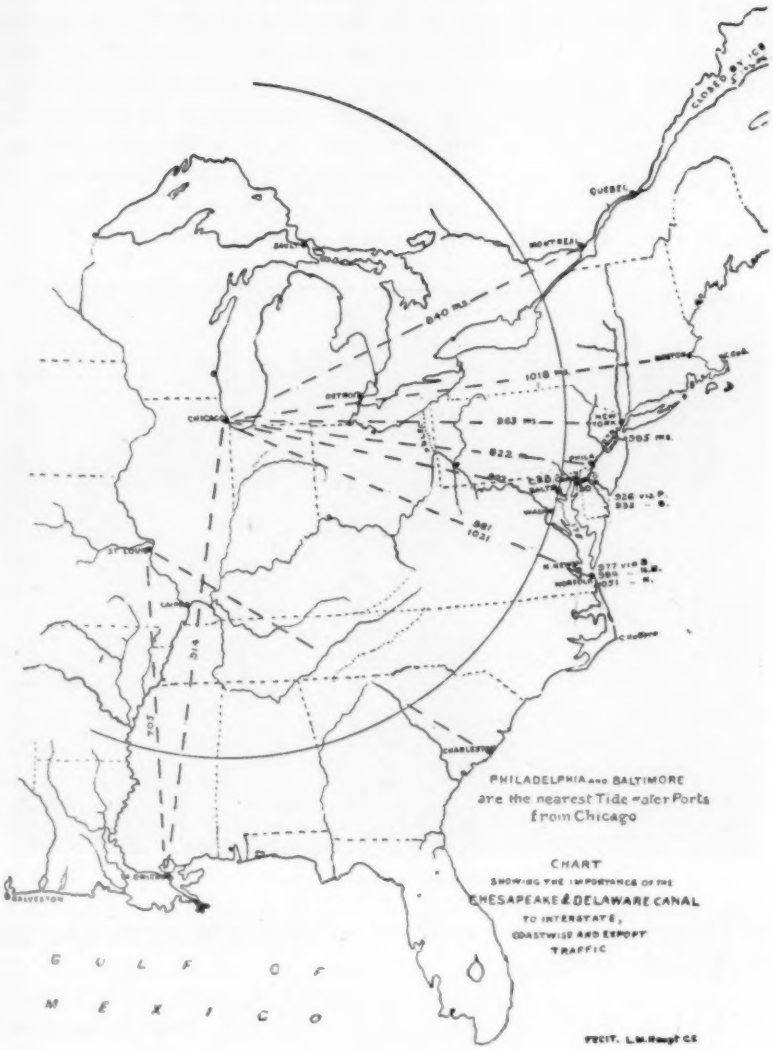
7. Industries and manufactures from New England to the Gulf of Mexico would be benefitted by the larger and cheaper shipments of fuel from the Cumberland and West Virginia fields, made through the Bay ports, if this canal was made large enough to pass ocean barges.

8. The differentials and exceptional facilities enjoyed by the Port of Baltimore, will attract the trade of the great West and draw vessels in ballast from northern ports through this short canal to that harbor.

9. The great necessity for this waterway has been under consideration for more than a century and its enlargement has been vigorously urged by commercial and trade bodies, by scientific and learned societies, by national boards and conventions and by officers and boards of the Army and Navy for many years.

10. Its superior geographical position and physical advantages have been attested by the unanimous reports of the many boards of engineers, both mixed and military, which have reported on the various solutions of this much mooted problem, and the conclusion has been reached, that, all things considered, the route which lies in the track of coastwise commerce and within the range of the defense is the best.

11. It has apparently not gotten beyond the stage of good resolutions, surveys and reports, by Congress, because of the excessive demand for National appropriations for other and less profitable purposes; yet it would seem from the above considerations, that there is no possible improvement, within the Federal domain, which would be more beneficial to a larger number of interests, both in peace and war, at so small an outlay as this; and as a business proposition it has no parallel, either in utility or economy, in any part of the globe, cost alone considered.


QUEBEC
MONTREAL
840 MS.
1018 MS.
863 MS.
822
905 MS.
926 via P.
938
891
1021
977 via B.
1031
CHICAGO
DETROIT
ST. LOUIS
CHARLESTON
GALVESTON
PHILADELPHIA and BALTIMORE
are the nearest Tide water Ports
from Chicago
CHART
SHOWING THE IMPORTANCE OF THE
CHESAPEAKE & DELAWARE CANAL
TO INTERSTATE,
COASTWISE AND EXPORT
TRAFFIC
G U L F O F
M E X I C O

12. The U. S. Engineer's estimate of 1883 for the Chesapeake and Delaware route, of $7,605,471, is composed of two parts, of which $4,388,797 is for the canal proper and the balance $3,216,674 is for the approaches, which are beyond the jurisdiction of the canal company, so that it has been unwilling to expend a large sum to increase the capacity of its portion of the waterway without first securing some assurance of co-operation on the part of the Government to the approaches.

13. In brief, the Chesapeake and Delaware Canal Route is the shortest, cheapest, most navigable, least obstructed by ice

Towing coal barge to Baltimore

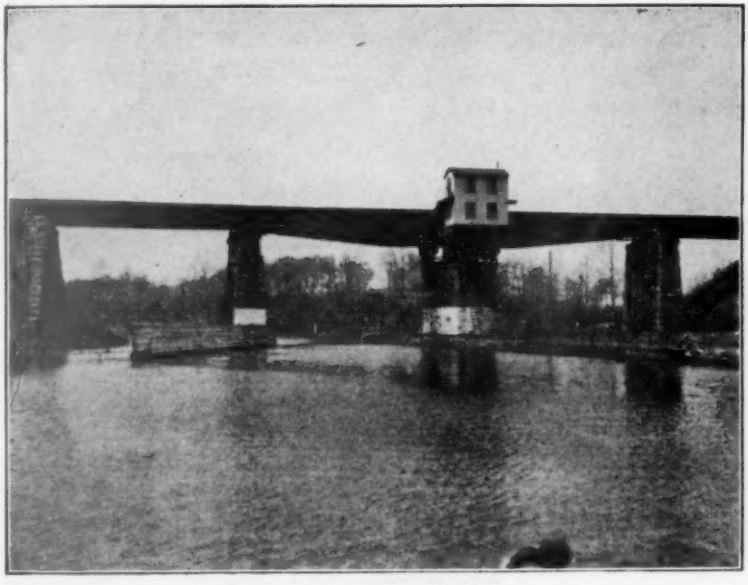
or bridges, most practicable to maintain and is immediately available for traffic.

Why should the Government expend on other routes many millions more than it would cost to enlarge the Chesapeake and Delaware Canal, with its superior advantages, and thus destroy the value of the property in which it is a large joint owner ?

In further elaboration of the condensed theses giving reasons why the present Chesapeake and Delaware route was the

better, some illustrations from the history of the country were cited as to the effects due to the absence of such a water communication during the War of 1812, and the benefits derived from its existence during the Civil War, as follows:

It is well known that our Atlantic and Gulf coast cities are within easy steaming range of the foreign naval bases at Halifax, Bermuda, Kingston, Saint Lucia, and other places, and that the most vulnerable points of our seaboard are the various bays and sounds which indent the coast. To protect these



Delaware R. R. drawbridge

efficiently, a very large navy is necessary unless we can operate upon interior short bases.

In 1812 the British fleet forced the *"Constellation"* to take refuge in Norfolk harbor, where she remained during the war. The mouth of the Delaware was blockaded by three vessels, while four more of the enemies ships cut off the coast trade between New England and the Southern States. The lights were extinguished and the people of the coast realized their defenseless positon. The Eastern Shore was pillaged by Admiral Warren, while Cockburn attacked and burned the villages

at the head of the Chesapeake Bay and destroyed Cecil Furnace where our guns were cast. Norfolk and Hampton were also attacked and the cities of Richmond and Washington threatened.

In the North the *"Decatur"* was penned in New York harbor, and by September, 1814, all of Maine east of the Penobscot had been captured and annexed to New Brunswick. Nantucket, reduced to famine, capitulated to remain neutral, if given clothes and provisions. Castine, Belfast, Hampden,

Towing five barges of cross ties for P. R. R.

Machias and Bangor yielded to a superior force. Many towns paid a ransom. Stonington was destroyed and New England was greatly alarmed, and ready to secede. Cockburn and Lord Ross then returned to the Chesapeake and on the 24th day of August, 1814, destroyed the National Capital and many of its records by fire.

Our thousands of coasters and ten thousands of sailors were driven from the seas, and the coastwise traffic was forced to take the inland route over mud roads in the so-called "schooners," of which there were about 4,000 by the end of the

war. When the roads were passable it required 26 days to cover the distance from Boston to Baltimore and 33 days more to Augusta, Ga., making two months in all. Provisions rapidly rose in price, money became extremely scarce, the National Bank failed, and the country was in desperate strait when the news was received of the signing of the Treaty of Ghent. These events served to impress upon the country the necessity of connecting our coastwise waterways by navigable canals and led to the completion of the Chesapeake and Delaware Canal as the greatest and best work of the times. Its enlargement is even more necessary to-day to meet the urgent demands of coastwise commerce and national defense.

In 1892 General Craighill, ex-Chief of Engineers, wrote: "If a connection be made between the two bays north of Baltimore, it would be much better to have it by an enlargement of the existing canal, to the construction of which the United States has already contributed, rather than to open a parallel to it so near as the Sassafras route, which has been strongly advocated by others interested in it."

Still later, in 1898, he wrote: "My opinion is very decided that the system of coastwise canals should be enlarged so as to be available for use by the Navy and vessels of commerce, especially in time of war, and for this and other reasons, should be controlled by the United States." Thus this distinguished officer urged the enlargement and emancipation of this particular canal for commerce and national defense. Is it necessary for this nation to engage in a war to convince Congress of the necessity of enlarging and emancipating our interstate channels from tolls in behalf of commerce, domestic trade and rate regulation?

Again the city of Baltimore took official action by the passage of a resolution, March 17th, 1894, calling upon the Engineer of its Harbor Board for a report upon the Maryland and Delaware Ship Canal, which he submitted on the 26th of of the same month, and in which he states, *inter alia*, "Studies have reduced the available routes to three. * * * As the same advantages and disadvantages pertain to each of the northern routes, it would appear that if either be adopted it should be the less costly. * * * The importance of a shorter route to the ocean for the coastwise and trans-Atlantic

commerce of Baltimore is too obvious to require argument; it is also of importance in an equal degree to the large territories of the Northwest, which find here the nearest point for the shipment of their products to Europe."

As a practical illustration of the great utility of the existing canal to the port of Baltimore for northern commerce, the statement of the agent of the New York and Baltimore Transportation Line is quite pertinent, since this company ran two lines of boats to New York, one via the canal and Delaware River rounding Cape May, and the other via Chesapeake Bay rounding Cape Charles. It was found that the time required by the canal route was only half that taken by the bay boats.* Another remarkable fact is stated to be the detention from ice which is actually found to give more trouble to the fleet using the lower bay route than to that using the canal. This opinion is based upon the use of the canal by that company for fifty years, and hence the agent of that line claims that "it is worth something."

The attitude of the far-sighted, patriotic and progressive citizens of Baltimore is further shown by the interest manifested in the project by the former President and Receiver of the Baltimore & Ohio R. R., Mr. John K. Cowen, who before investigation thought that the Sassafras route was the best, but after a careful personal investigation he went before the Congressional Committee and urged the enlargement of the Chesapeake and Delaware route, as being the most advantageous for the interests of the country served by his line, as well as for Baltimore. He distinctly stated that with this present canal enlarged and made free his company would ship its New England coal from the Port of Baltimore and in that event the railroad could haul as much in one car as now required two and a half. And, he added:

"I thought the Casey Board, in recommending the Chesapeake and Delaware Canal route, had overlooked the very largest item of coastwise commerce that would pass through the ship canal. I am prepared to say that directly from the Baltimore and Ohio Railroad at least two million tons of coal destined to New England ports, would pass through it, that this

*See Ex. Doc. 102 53d Cong. 2d Sess. H. R., p. 105.

tonnage would probably increase until it more than doubled the two million figure, and further, that coal to the extent of a million tons, now going via rail to New York harbor, would probably go in vessels via the canal instead."

This was in January, 1901. Thus more than 5,000,000 tons of coal would be distributed at a saving of over a dollar a ton if the canal were enlarged as desired by the consumers and manufacturers of the country. This great economy of $5,000,000, on one item of commerce, would justify an expenditure of

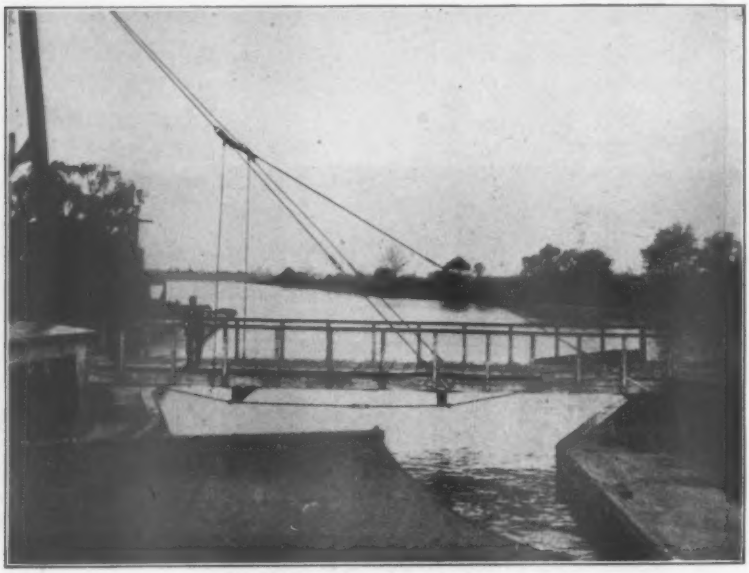
Ericsson line steamer, passenger and freight. Daily trips, Baltimore-Philadelphia.

$100,000,000 if capitalized at 5 per cent. The existing canal is an insuperable barrier to vessels requiring more than ten feet of water, and commerce importunes Congress for its removal.

FACILITIES FOR CONSTRUCTION.

Although this canal is but 13⅜ miles in length, only one-fourth of this distance involves any considerable amount of work, as the route occupies the bed of several creeks and it is only necessary to pump the mud from the bottom over the

dike which forms the tow-path and fill up the swampy reaches, thus converting them into arable lands or commercial frontages. The "deep-cut," which is a little over three miles long, and seventy-six feet deep at the summit, was excavated in 1826-9 by hand labor, and gave some trouble until the slopes had assumed a condition of equilibrium, but for the past 20 years or more there has been no difficulty in maintaining the full depth of the channel. During the past 25 months the average dredging done to remove the wash from the steamers was but 28 cubic yards per diem in this cut.



Common road swing bridge, Delaware City.

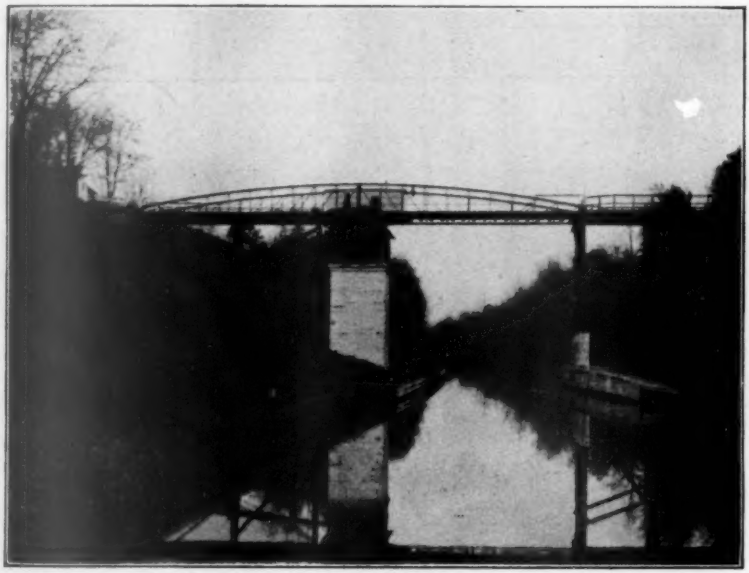
Borings made under the several surveys have revealed no rock in place and the existence of the waterway enables the work to be attacked at any point by hydraulic dredges and thus reduces greatly the cost of the enlargement, as well as the time for completion.

Neither is it necessary to suspend navigation.

The summit level, which is 16 feet above mean low water, is surmounted by two locks, one at Delaware City of 6 feet on the east, to overcome the tides, and another at St. Georges of 10 feet lift to reach the upper level, while the entire lift is

comprehended in a single lock at Chesapeake City on the western end, where a reservoir serves to save half of the water required for lockage. The deficiency in the supply is furnished by two large engines which lift the tidal water from Back Creek by means of a large bucket wheel.

The auxiliary works consist of the usual bridges, reservoirs, drains, wiers, siphons, locks, buildings, &c., which, with the



Swing bridge at Summit (Buck's)

excavations and enlargements, are estimated to cost about $5,000,000, exclusive of the franchises.

TRAFFIC.

On the present limited draught of ten feet the enormous tonnage of the two bays cannot use this route and is compelled to go outside, involving great loss of time, risk and expense. The official reports of the U. S. Engineers show that there are about 50,000,000 registered tons of commerce in the waters immediately tributary to the Chesapeake and Delaware Bays, and of this only about 700,000 freight tons can use the canal. If it were deepened to 20 feet even, then 75 per cent. of the

vessels could pass through, and many of them would doubtless soon do so if there were no obstructing tolls. In this case there would be an enormous traffic, while the railroads would

Three oyster sloops in St. George's Lock.

be relieved of the bulky freights at the nearest seaports and be enabled to utilize their rolling stock to much better advantage, not only because of the shorter haul but because of the higher class freights carried.

The precedent furnished by the Sault Canal since its several enlargements should suffice to show that the commerce grows faster than the Government can provide facilities and that absolutely no interests are injured thereby.

If the railroads and the people fully appreciated the benefits to be derived from a segregation of the bulky freights, wherever possible, from overland carriage, the conditions of traffic would be greatly improved for the good of all interests.

To effect this result, opposition to waterway legislation must be removed and a far more comprehensive system be inaugurated for the conduct of these works on a broad basis, by dividing the country into districts based upon the drainage systems, and appointing permanent officials, with sufficient authority to conduct the local improvements, but at the same time giving every possible latitude to all private and corporate efforts to make improvements at their own cost and risk, as has been done so successfully in the rail and common road systems of our country.

PRODUCTION OF BORAX IN 1905.

The production of borax, says Mr. Charles G. Yale of the United States Geological Survey in his report on the output of that mineral during 1905, is now almost entirely confined to the State of California, and to the counties of San Bernardino, Inyo, and Ventura in that State. Only small quantities are occasionally taken from the marshes of Nevada, where a little work is carried on during the summer months.

The total output of crude borax for the year 1905 was 46,334 short tons, valued at $1,019,154, as against 45,647 short tons, valued at $698,810 in 1904, an increase of 687 tons in quantity and of $320,334 in value. The average value of the crude borax product in 1905 did not actually increase in this ratio to the somewhat increased quantity, so that an explanation of the figures given is due those whose interests the statistics may serve.

In the process of manufacturing borax and boracic acid, it takes from 2 to 4 tons of crude borax to make 1 ton of pure anhydrous acid, depending on percentage of the ores handled. When the crude product, worth at the mines from $15 to $50 a ton, is refined, it is worth on the market, as a manufactured product, from $120 to $140 a ton. When mined and shipped none of the material is pure borax and about six-sevenths of the total is only 25 per cent. ore, the other seventh being more or less concentrated but not refined. The miners themselves agree that in calculating the quan-

tity and value of the product for statistical purposes the crude material only should be considered, as the costs of refining vary with the process.

The valuable element in the crude borax of California is anhydrous boric acid, of which the prepared borax of commerce contains 36.6 per cent., the other elements being soda and water added in the process of refining. The manufactured product is worth from $120 to $140 per ton, but the boric acid content and its fair commercial value at the place of production are evidently the only proper considerations for the statistical purposes of this service. The crude material as it comes from the ground varies in boric acid content, according to the nature of the deposits, from about 5 per cent. to about 35 per cent. Under the conditions the uniform plan of calculating the value of the crude material according to the percentage of boric acid contained has been accepted, and, with the advice of leading producers, it has been assumed that this product in 1905 was worth $120 a ton at the mine, making the crude material worth $1.20 for each unit, or per cent., of boric acid carried. This percentage is reliably known for each mine. Some of this boric acid is used as such in the industries, but the bulk of it goes into the manufacture of borax. Had the entire output been made into borax, the resulting refined product, at an average value of $130 a ton, would be worth $3,016,260.

The figures given for 1905 represent the total tonnage of crude material, regardless of its percentage of boric acid, and the value based on the boric acid content of this crude material.

Mr. Yale's report is published as an advance chapter from the annual volume "Mineral Resources of the United States, 1905," and is intended for general distribution.

PRODUCTION OF CHROMIC IRON ORE IN 1905.

California was the only State producing chromite during 1905. The quantity produced was 25 long tons, valued at $375, as compared with 123 long tons, valued at $1,845, in 1904, with 150 long tons, valued at $2,250, in 1903, with 315 long tons, valued at $4,567, in 1902, and with 368 long tons, valued at $5,790, in 1901.

PRODUCTION OF PLATINUM IN 1905.

The production of platinum from domestic ores in 1905 was 318 ounces, valued at $5,320, as compared with 200 ounces, valued at $4,160 in 1904; with 110 ounces, valued at $2,080 in 1903; with 94 ounces, valued at $1,814 in 1902; with 1408 ounces, valued at $27,526 in 1901; and with 400 ounces, valued at $2,500 in 1900. In December, 1904, the price of ingot platinum at New York advanced from $18.50 to $19.50 an ounce; in April, 1905, it was $20.50; in February, 1906, it advanced to $25, and in September, 1906, it was $34 an ounce.

Mining and Metalurgical Section.

(Stated Meeting, held Thursday, March 8th, 1906.)

The Manufacture of Rolled Sterling-Silver.

By Erwin S. Sperry,

Editor of "The Brass World," Bridgeport, Conn.

Within the past twenty-five years the manufacture of sterling-silver has undergone a remarkable change. It is not difficult to remember when an article of this metal was considered a household luxury and only the wealthy could afford it. Well-to-do people possessed a small quantity, handed down as an heirloom, perhaps; and people in moderate circumstances had to be content with pewter or tin-ware for common use, with a meagre assortment of plated-ware for special occasions. On particular occasions, the family heirlooms of sterling-silver, which usually consisted of one or two table-spoons and half a dozen tea-spoons, were carefully cleaned and polished and arranged on the table so that they would make the best showing. After such service they were returned to their former hiding place to prevent theft.

This unique condition has now changed. Instead of being confined to the wealthy or well-to-do people, sterling-silver is found in even large quantities in families who in former times would have been considered extravagant had they possessed the stock which they now have. The reason for this apparent paradox is not the reduction in the price of silver, but in the cost of manufacture.

The method pursued by the old-time silversmith for making spoons or forks was to hammer them out by hand from a rod. By means of files and saws the article was made to assume its shape. No doubt, the reader has seen examples of this early silversmithing and has noticed the marks of the hammer upon

them. Costly operation that it is, our British friends still continue to use it for the manufacture of their wares. Even in our own progressive country, a few manufacturers continue to manufacture goods in this manner, but only upon work which will warrant it. Such work is always upon special designs which would not warrant the necessary expense for dies.

The change which has been responsible for the cheapening of sterling-silver wares is the use of *rolled sheet metal* for its manufacture. Articles which heretofore were made from rods are now made by stamping from sheet metal and with the employment of modern machinery instead of hand labor. This sheet metal is the foundation of the manufacture of modern sterling-silver ware, and it is my intention to describe the various operations employed for its production.

Trade conditions at the present time are such that it hardly pays the manufacturer of sterling-silver wares to make his own sheet metal, and nearly all of the establishments of this nature in the United States now purchase the sheet from mills that make a specialty of rolling. The condition is analogous to that which exists in the brass trade. It has been found that the manufacture of the sheet metal and the production of finished wares are quite distinct, so that the present policy of the sterling-silver manufacturer is to purchase his sheet metal and not manufacture it. The fact that a large and extensive equipment is required for the manufacture of rolled sheet metal is usually a sufficient reason why the majority of manufacturers do not care to make it.

Sterling-silver, as now made in the United States, consists of 925 parts of pure (fine) silver and 75 parts of copper. Pure silver itself is too soft for use in articles which are to hold their shape. At the beginning of the so-called "cheap silver era," or when sterling-silver ware began to be manufactured by modern methods, a manufacturer occasionally was found who cheated the purchaser by making ware with less than 925 parts of silver in it. To-day, however, no one would dare to do this. Laws in several States regulate the quantity of silver which an article stamped *sterling-silver* must contain. These laws do not stipulate the alloy nor the exact proportions, but state that not less than 925 parts of fine silver shall be present in 1000 parts of metal.

The silver which is used in the manufacture of sterling-silver sheet is known as *fine silver bars.* It is also called *bullion,* but as bullion may mean impure silver as well as the pure material, it is now customary to designate the metal that is employed for sheet rolling by the former name. These fine silver bars are purchased from the various smelting works that smelt silver ores. The electrolytic copper industry also furnishes a supply. These bars are received from the express company (all bullion is transported by express) in a loose condition, as

Fig. 1. 500 Oz. Bars of Fine Silver Valued at Over $10,000.

it has been found easier to watch or verify them if sent in this manner. When the bars are received from the express company they are loaded upon a mill truck as shown in Fig. 1 and immediately counted. Any loss, therefore, is detected at once.

The fine silver bars which are shown in Fig. 1 are known as "500 oz. bars," on account of their weight. Such bars have been found to be the most convenient. Bars may also be obtained weighing 1000 and 200 ounces. The value of silver needs no explanation and every precaution is taken to prevent theft. The bars which are shown in Fig. 1 have a value of over $10,000.

The bars are now immediately weighed upon bullion balances, as shown in Fig. 2, in order to ascertain whether the correct amount has been received. If any bar has been tampered with the loss is at once apparent. The balances are capable of weighing as small an amount as 0.01 oz. Troy, which is sufficiently accurate for the ordinary weighing of silver.

The storing of large quantities of silver, both in the form of

Fig. 2. Weighing the Fine Silver Bars When Received.

bullion or in process of manufacture, is a problem which has had to be solved, as it is not unusual for silver to the value of several hundred thousand dollars to be partially completed. This problem has been solved by the use of a vault. The vault which is commonly used for this purpose closely resembles a bank vault. It is both fire and burglar proof. The inside brick walls are filled with fine copper wires so that the rupture of any one of them, that would take place should an attempt

be made to enter the vault, is at once made known at some central station.

The "fine silver bars" which are used for the manufacture of sterling-silver and which are shown in Fig. 1 are always stamped on the bottom with the weight, number and fineness. The mark used to designate the fineness is always the same and no attempt is made to raise the fineness of the silver beyond 999 parts in a thousand. It has been found not only quite expensive but unnecessary to raise the fineness beyond the 999 point, and silver of this purity answers every requirement. It is such silver, 999 fine, that is used in the manufacture of sterling-silver sheet.

In Fig. 1 are shown 500 oz. bars. Bars weighing 1000 oz. and 200 oz. may also be obtained, but it has been found that the 500 oz. bars are the most convenient for use. The 1000 oz. bars are too large for crucible melting. The 200 oz. bars are satisfactory, but more handling is required in using them, and, therefore, they are not extensively employed.

The fine silver bars shown in Fig. 1 are frequently known as *Commercial Silver Bars* to distinguish them from *Assay Bars* made by the United States Government. *Assay Bars*, however, are no better than *Commercial Bars* and experience has demonstrated that no better results can be obtained by their use. Our Government does not sell silver, and in order to obtain Assay Bars it is necessary to place a certain amount of silver in the Assay Office in New York City for refining. The quantity of silver, 999 fine, which is obtained from it is returned to the depositor and a refining charge is made. The Government stamp upon them, to many persons, would seem to indicate that the silver is better than Commercial Bars, but such is not the case. The Government makes no attempt to raise the fineness above 999.

In the manufacture of sterling-silver which, as previously mentioned, consists of 925 parts of fine silver and 75 parts of copper, it is customary to use shot copper. This variety of copper is made by melting the purest copper that is obtainable (Lake copper) in a graphite crucible and then pouring it at a considerable height into cold water. The copper cools in the form of shot. In Fig. 3 is shown a batch of shot copper ready for use. The fine state of division of this variety of copper

renders it a simple matter to make up any given weight. The copper which is used in making sterling-silver is called the "alloy."

The fine silver and the shot copper are now weighed upon accurate bullion balances in the proportions which are necessary to produce sterling-silver. In the majority of sterling-silver mills it is customary to use a No. 40 graphite crucible for melting the silver and this holds about 1200 oz. As a large amount of scrap constantly accumulates, the amount of fine silver and shot copper that are weighed are sufficient to fill

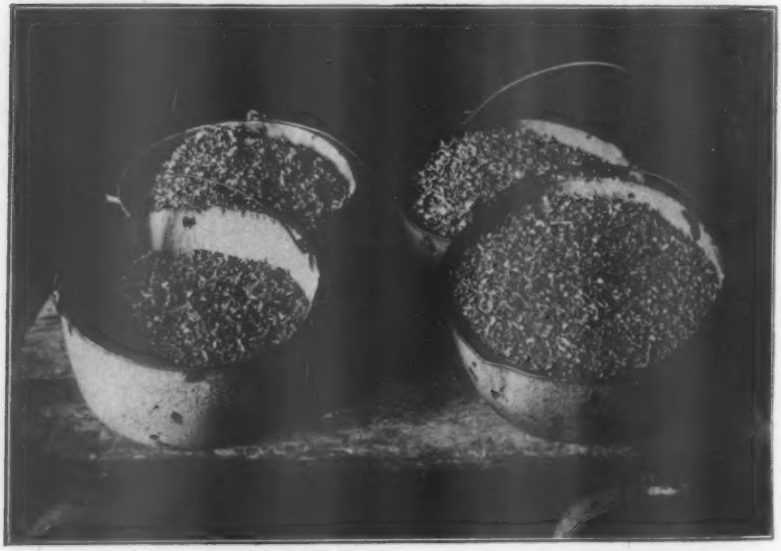


Fig. 3. Shot Copper Used in Making Sterling-Silver.

only half the crucible. The remainder is filled with scrap. A small amount of copper oxidizes in melting so that while the original fineness may have been 925, after the sterling has been cast, the fineness will frequently be found to reach 926 or even 927. Allowance is made for this oxidation. One or two thousandths, however, are usually considered as close at it is possible to make sterling-silver when considerable scrap is used.

The copper is placed in the bottom of the crucible and the silver on top. No scrap is put in at this period but is with-

held until the copper has melted. The silver having a lower melting point than copper, melts first. When the silver begins to melt, charcoal is added to the crucible so that it completely covers the metal. This is imperative, as without it the copper would oxidize.

The crucibles which are used are of the ordinary variety employed for brass melting. In some establishments a crucible known as a "Tube-Nosed Pot" is used. This is a crucible with a tube down the side which renders it self-skimming. Beyond the advantage of skimming they have no value and silver

Fig. 4. Oil Furnaces Used for Melting Sterling-Silver.

manufacturers seem to differ about their value in melting. Personally, I have found them quite advantageous, but many silver makers have not found them so.

For melting the silver, crude oil has been found to be very satisfactory. Its freedom from sulphur and the fact that it produces no ashes have greatly appealed to the sterling-silver maker and at the present time nearly every one in the United Stats uses it for this purpose. It is cheaper than gas, although not as convenient. The cost of a good quantity of gas has prevented its use in the manufacture of sterling-silver. The fact

that coal or coke leaves ashes to be ground has brought about the use of oil for melting. The value of silver is so great that every particle must be saved. The constant accumulation of ashes, therefore, which invariably contain more or less silver, has always been a difficult problem, but the use of oil has solved it.

The furnaces used for melting sterling-silver are a shell of cast iron lined with fire brick. A burner enters at the bottom and strikes at a tangent so that the flame does not directly impinge upon the crucible. These furnaces are shown in Fig. 4. When everything is in good working condition, the melting operation usually takes about forty minutes. Air is used for spraying the oil and the noise which this blast produces is one of the objections to the use of oil. The melters, however, soon become used to it.

As the silver melts before the copper and settles to the bottom of the crucible, great care is required in ascertaining whether all the copper has melted. A rod of graphite crucible mixture is used for stirring the mixture, and this is frequently done by the melter to make sure that all the copper has melted and alloyed with the silver. Charcoal is added to the crucible when needed and care is taken to see that the surface is not exposed at any time. When the copper has melted and the mixture has reached the required temperature, it is ready for pouring. The determination of this "pouring heat" is an operation which requires skill, and unless the melter understands his business good sterling-silver cannot be made. Too low a temperature will result in a cast plate full of "cold-shots," while one poured when the heat is too high will result in blow-holes and the cracking of the metal in rolling. Pyrometers have not been extensively used for the determination of the pouring temperature, but they will undoubtedly be largely employed as soon as one is found which is capable of giving accurate and uniform results in inexperienced hands.

When the sterling-silver is ready for pouring, the crucible is lifted from the furnace by two men by means of basket tongs and is immediately poured. In Fig. 5 the operation of pouring a sterling-silver plate is shown. The crucible which is shown is of the "tube-nosed" variety.

The mold that is used is of cast iron and in halves so that the

plate may readily be removed. It is held together by means of an iron band and wedge. The mold is coated with whale oil before using. A good sized stream is used in pouring so that the mold is rapidly filled. No attempt is made, as it is in the brass industry, to fill the "shrink" at the top of the mold. Sterling-silver shrinks very little in cooling and only a slight depression is found on the top of the plate.

This pouring operation is supposed to be one of the

Fig. 5. Pouring a Sterling-Silver Bar or Slab to be Used for Rolling.

"secrets" in the manufacture of sterling-silver; but, as a matter of fact, the only "secret," if it can be called such, is in the determination of the pouring temperature. At the present time this point is determined by the eye, but it is quite probable that the advent of a suitable pyrometer will reduce the operation to a business basis.

One of the former "secrets" in the manufacture of sterling-silver, but now common property, is the use of cadmium for imparting soundness and malleability to the metal. It is customary to add 5 parts of metallic cadmium to 1000 parts of

sterling mixture. This amount is deducted from the copper so that the actual mixture becomes:

Fine Silver	925 parts
Shot Copper	70 parts
Metallic Cadmium	5 parts

The cadmium is added after the copper and silver have melted. It is pushed down under the metal with tongs so that it will not rise to the surface and burn. The function of cadmium is to remove the oxygen from the silver and in this respect it has been found so advantageous that it has replaced every other deoxidant and practically every manufacturer of

Fig. 6. The Bar or Slab of Sterling-Silver as Cast.

sterling-silver in the United States now uses it for this purpose.

The cooling of a large mass of silver in the air is a slow operation, so it is customary to plunge the plates after they have "set" and are removed from the mold, into cold water. This sudden chilling of the plate does not seem to have any bad influence on the rolling qualities of the silver, and by thus quickly cooling it work may be commenced upon it at once.

It is customary in the sterling-silver industry to cast one size of plate and then widen it if a wide sheet is required. In Fig. 6 a cast plate of sterling-silver is shown. This plate is 1¼ inches in thickness, 10 inches wide and 12 inches long. The

plate shown in Fig. 6 is just as it came from the mold. After the fins have been removed the top end is cut off on large alligator shears. The object of cutting this end is to remove the imperfect portion of the metal. The top is not so dense and sound as other portions, and if the plate is rolled without cutting off this end, imperfect sheet would be produced. It is quite difficult to detect such imperfect metal after the sheet has been rolled, so that the practice of cutting off the end before rolling has been adopted. This is called "cutting-off the gate." Usually one cut is all that is required, but now and then when the center of the plate is quite crystalline another cut has to be taken. The center of the plate is usually crystalline near the top and the object of the cutting of the end is to remove it. Dross, too, frequently rises and this is likewise removed when the gate is cut off.

The plate is now ready for "overhauling." This operation has long been used for removing the surface of a plate before rolling. No one has yet devised a process for casting perfect metal, and although sterling-silver runs freely and without oxide, the surface of the plate is never clean. Charcoal, slag, or pieces of crucible are always found on the surface of the cast plate.

The overhauling machine consists of a bed similar to a planer bed upon which the plate is clamped. An overhanging arm carries a tool which is made to scrape the surface of the plate by means of a crank and cam. The tool may be made to take a heavy or light cut by means of a treadle manipulated by the operator. The fact that any particular portion of the plate may be scraped more than another is wherein the overhauling machine differs from a planer. A planer removes an equal amount of metal from one end of the plate to the other, while the overhauling machine enables the operator to remove the metal from any particular portion which may require it. It often happens that certain portions of the plate require no scraping while others have to be scraped deeply in order to thoroughly remove an imperfection.

After the plate has been overhauled, it is ready for the first rolling operation called "breaking-down." The rolls which are used for this purpose are of chilled iron and ground with a smooth surface. As the object of this breaking-down pro-

cess is to reduce the metal as rapidly as possible, the rolls and housings are made sufficiently strong to bear the strain which is put upon them. This "breaking-down" process does not require as skilled labor as finishing the metal and the wages are correspondingly less.

All sterling-silver is rolled cold and the plate is passed through the rolls with as heavy "pinches" as can be given it. A "catcher" stands behind the rolls and passes the plate back to the roller after it issues from them. In Fig. 7 is shown the

Fig. 7. "Breaking-Down" the Sterling Silver. First Operation in Rolling.

breaking-down operation. The plate is rolled to a thickness of $\frac{3}{8}$ of an inch in this "breaking-down" operation. If a wide sheet is required, the plate is passed through the rolls diagonally so that the metal is widened and lengthened at the same time. This widening operation is called "cross-rolling."

The rolls shown in Fig. 7 are 18 inches in diameter and 30 inches long. The adjustment is by means of a crank at the left hand side of the rolls. Both ends of the rolls are raised and lowered at the same time. This adjusting mechanism

answers very well for "breaking-down" rolls, but for finishing rolls, an overhead adjustment by means of screws and "spanners" are the best.

After the plate has been "broken-down" to ¾-inch the metal has reached the limit of rolling and any further reduction would tend to injure or fatigue it. In order to overcome the hardness which the rolling has imparted to the plate and to

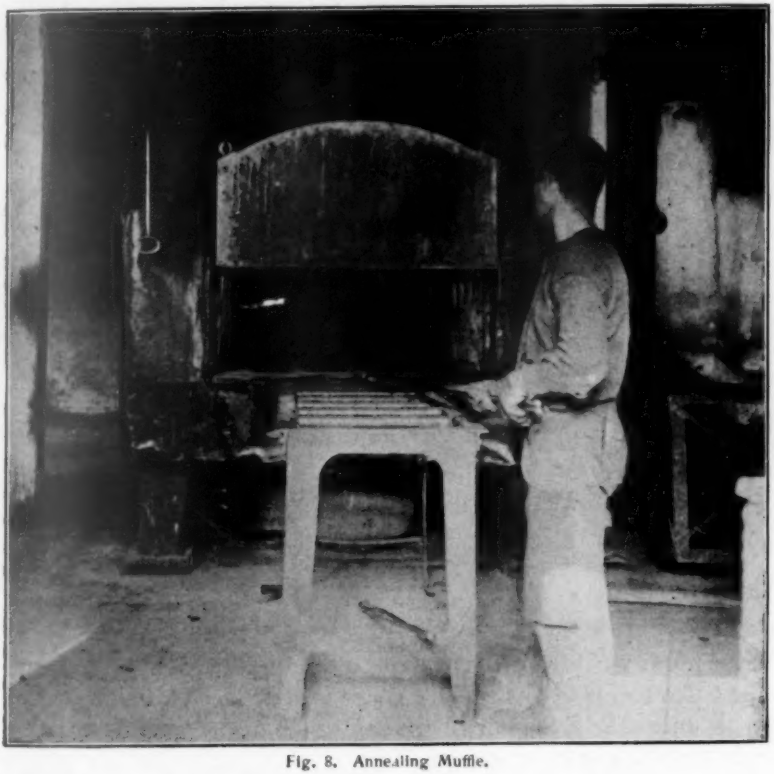


Fig. 8. Annealing Muffle.

soften it so that further rolling may be done, the plate is annealed.

The annealing is carried out in a muffle (shown in Fig. 8) lined with fire brick and heated with oil. As soon as redness has been reached the plate or sheet, which it now is, is plunged into a sulphuric acid pickle. This pickle is composed of sulphuric acid (oil of vitriol)

and water in the proportion of about one part of acid to sixteen of water. The sheet is plunged while it is red hot into the hot pickle and in this manner the black oxide of copper which forms on the surface during the annealing is removed in a few seconds. The sheet is then rinsed in water and dried. As it has been found that silver is injured by allowing it to remain too long while red hot, great care is required in annealing to avoid excessive heating. The simple heating to a red heat is all that is required. The pickle which is used dissolves some of the silver as well as the oxide of copper which is on the surface. At frequent intervals salt is added to the pickle, and the precipitated chloride of silver is allowed to settle and is then removed.

The pickled sheet now presents a uniformly white surface and without lustre. Any imperfections which have developed during the "breaking-down" are now plainly revealed and are removed by a second overhauling and an operation called "chipping." This "chipping" operation consists in removing small particles of charcoal or similar imperfections which have become bedded in the surface. A hammer and chisel are used for the purpose, but care must be taken so that the hole which is produced will not fold over on itself in the next rolling. By making the hole dish shaped the edges will not fold over.

The sheet of sterling-silver after it has been annealed and pickled is warped so that it will not lie flat upon the table of the overhauling machine. The sheet is therefore straightened upon a machine known as a "three-roll straightener." This appliance consists of three rolls arranged in pyramid form, that is, with two rolls at the bottom and one at the top. In order to use them it is first necessary to curve the sheet and then adjust the top roll so that the sheet is flattened. This operation is frequently explained by saying that the sheet is "first made sick before it is made well."

After the sheet has again been overhauled, it is ready for the next rolling operation, called "running-down." The rolls which are used for this purpose are the counterpart of the "breaking-down" rolls but are kept in a better condition. The "running-down" process consists in rolling the sheet to No. 10 B. & S. gauge. The sheet is then elongated so that it requires coiling before it can again be annealed. The sheet is usually

10 or 12 feet long. Another annealing is then given it followed by pickling, and the sheet is then carefully inspected for further imperfections. If any are found they are removed by means of a hammer or chisel. Deep chipping must now be avoided, however, and only superficial imperfections can be advantageously treated. In this manner the elimination of the chipping marks is assured, but deep holes will not be removed by the subsequent rolling.

The sheet is now ready for the final rolling process called

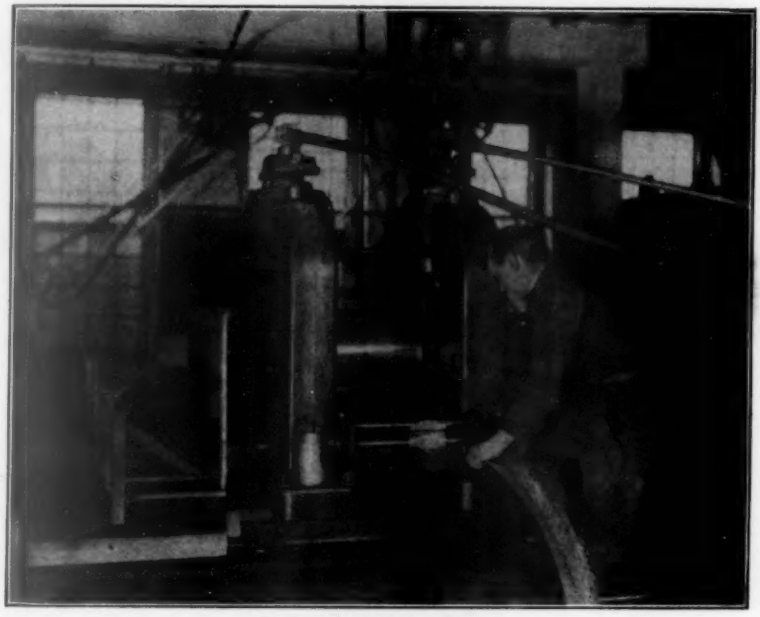


Fig. 9. The Finishing Rolls.

"finishing." The rolls that are used for this purpose are chilled iron, but the surfaces are kept in a more highly polished condition than either the "breaking-down" or "running-down" rolls. The adjustment is by means of overhead screws operated by long spanners so that one side of the roll may be raised or lowered independently of the other end. Any tendency towards crookedness in the sheet as it issues from the rolls may, therefore, be corrected. In Fig. 9 is shown a pair of finishing rolls in operation.

It is in the finishing of sheet metal that the skill in rolling is displayed. All spinning or drawing operations, in which sheet metal is used, demand that an accurate gauge shall be furnished. For this reason, the finishing roller must understand his business or great inaccuracy will follow. A device called a "bridle" is used for straining the sheet as it passes through the rolls. If this is not done the sheet cannot be kept straight. In wide sheets a "wedge" is used; this may be seen between the rolls and bridle in Fig. 9. The wedge and bridle are frequently used together, but the bridle can only be used for thin sheet. Neither can the wedge be used for thin sheet as the strain cannot be accurately adjusted and the sheet will tear. The bridle, however, enables the roller to adjust the tension so that the thinnest sheet may be rolled.

Back of the rolls is a wooden cylinder attached to a revolving shaft. The sheet as it comes from the rolls is attached to this "block" and a coil is thus produced. A band of copper wire prevents it from springing apart. As practically all sterling-silver sheet is sold in the annealed form, the coil is now returned to the annealing muffle and again annealed and pickled. More care is now exercised in the handling to avoid scratches or dents and when the coil comes from the rinse water it is dried in maple sawdust so that a uniform surface is produced. An appliance called a "drying-out machine" is employed for this purpose. It consists of a long box in which sawdust is placed. On one end is a coiling drum operated by a belt. The sheet is started through the sawdust and attached to the drum which draws it rapidly through. Revolving brushes remove the surplus sawdust from the sheet after it issues from the box. Pine sawdust cannot be used for this purpose, as the pitch which it contains leaves streaks upon the surface of the silver. In order to obtain the best results, the sawdust is used warm and a steam coil underneath the box heats it to the required temperature.

As the various articles which are made from sterling-silver require varying widths, it is necessary to slit the sheet to the required dimensions. A rotary slitting machine is used for this purpose and both sides of the sheet are trimmed at once. If great accuracy is not required in the width of a sheet, it is preferable to slit the sheet before it goes to the finishing rolls.

Fig. 10. Inspecting the Sheet.

The object of this procedure is to avoid scratches or dents, which invariably are produced when a soft metal like sterling-silver is handled. The surface after annealing and pickling is dead white and is particularly susceptible to abrasion. In Fig. 11 the finished sheet may be seen and the dead white surface is quite apparent. The need for careful treatment is, therefore, far greater than in brass or german-silver.

The final operation is the inspection of the sheet, and as no requirement is more severe upon a metal than spinning or

Fig. 11. The Finished Sterling-Silver Sheet Ready for Shipment.

drawing, nothing but perfect sheet can be allowed to go to the customer. In Fig. 10 the inspecting operation is seen. The sheet is unrolled upon a bench and every part of the surface is searched for imperfections. The specks of dirt often deceive the inspector, but a little scraping with a knife will reveal their true nature. If it is found that the imperfections are such that the sheet is injured, the whole is cut up and remelted. It usually happens, however, that sheet is sold in short lengths, so that by judicious slitting or trimming the imperfections may

be removed. The sheet is now rolled into coils as shown in Fig. 11 and is ready for shipment.

A word about the grinding of the rolls may be of interest. This operation is one of the most peculiar in the rolling mill industry. One would naturally think that an emery wheel could be rigged so the rolls could be ground in place, or if not, it is a simple matter to remove them and grind them in a lathe. While both of these methods are used for grinding the rolls before they are inserted in the housings, they do not answer for the production of the required surface. The method which is now pursued for grinding a pair of chilled rolls that are used for cold rolling silver, brass, or copper is by means of a hard wood stick and emery. The stick is covered with oil and emery, inserted between the rolls and moved gradually from end to end. The object of this apparently primitive method is not to produce a polished surface upon the rolls as one might naturally think, but to impart the necessary "crown" to the rolls. Although chilled rolls seem proof against any bending, it is an actual fact that they do spring when a piece of metal is rolled. If, therefore, a pair of rolls were used with a "flat" surface, i. e., straight from end to end, the "spring" would cause the rolls to become concave and a sheet would thus be produced which would be thicker in the middle than on the edges. In order to guard against this unevenness of gauge, the rolls are ground so as to allow for the amount which they "spring."

As the thickness, width, and hardness of the sheet which is to be rolled, cause the rolls to "spring" to a varying amount, it is obvious that a uniform "crown" cannot be given to them. It is in the grinding of the rolls that the skill in rolling is displayed and a roller who can grind a pair so that a sheet of metal will have a "lay" to it and with uniform gauge, is worthy of the name of an "expert roller." The most difficulty arises in rolling wide sheets and only those who are highly skilled in the art of rolling can roll sheet of this character.

MEASUREMENT OF NATURAL GAS.

Statistics of the quantity of natural gas consumed in the United States will be taken next year by the United States Geological Survey. Up to the present time, only the value of the gas has been ascertained. The adoption of this method will make it inconvenient, if not impossible, to refer back for purposes of comparison to the figures of previous years, but it will result in more direct knowledge of the capacity of gas areas to maintain a commercial supply of gas for a certain number of years.

An effort will be made to collect and publish statistics showing the total acreage held by natural gas companies and the acreage operated by them, with the total quantity of gas consumed in the different States. Owing to the fact that gas wells from different fields are connected to the main pipe lines, and that gas is only measured where consumed, it is now almost impossible to procure exact figures as to the quantity of gas produced from any particular district.

When natural gas was first brought into use an idea prevailed that the supply was inexhaustible. It was sold at low rates and usually without measurement. This method encouraged waste in the consumption of natural gas and was shortly abandoned by the larger companies. They introduced meters and sold their gas at a rate per thousand feet by measurement. There were, however, so many smaller companies that did not measure the gas consumed that it was impossible to secure reliable figures of the production and consumption of natural gas in thousands of cubic feet. For this reason the statistics of this valuable product have been collected in terms of value.

In taking only the value of the product, however, as a basis for statistical record an incorrect idea is given of the actual production of the gas fields, for with the diminution in volume the price has been increased, and in recent years in some cases an increased value is shown where there has been a decided falling off in the production of gas. Experience has demonstrated that there is a limit to the production of all fields, and those who handle the gas have learned that the unnecessary waste of this valuable resource must be prevented. To-day nearly all consumption is sold by measurement. It is believed that the time has come when it is possible to procure statistics of the quantity of gas consumed. Announcement of the Survey's intention to make the endeavor next year is contained in the recently published report by Mr. .W T. Griswold entitled "The Production of Natural Gas in 1905."

PRODUCTION OF LEAD IN 1905.

The production of lead in 1905 was 302,000 short tons, as against 307,000 short tons in 1904 and 282,000 short tons in 1903. The value of the production in 1905 was $28,690,000, as compared with $26,402,000 in 1904, and with $23,520,000 in 1903.

(Stated meeting held Thursday, December 20, 1906.)

The Efficiency of Furnaces.

By Dr. Joseph W. Richards.

"Efficiency" may be considered in many various aspects. The most general meaning is the quality of accomplishing the desired purpose at the minimum cost. This is a very complex quantity, and must be discussed from the most general and varied standpoints. Again, one furnace accomplishes a certain work with one-half of the fuel which another furnace uses, and we can therefore speak of the first furnace being *relatively* twice as efficient as the second, as far as fuel consumption is concerned. But, besides relative efficiencies, there is such a thing as *absolute efficiency*, when speaking of thermal efficiency; —that is, the ratio of the net thermal effect produced to the heating power of the fuel.

We will take up the subject first as regards *Thermal Efficiency*, both absolute and relative, and conclude with a discussion of *Efficiency* in its most general meaning, as relates to minimum cost.

THERMAL EFFICIENCY.

A view of efficiency which in many cases leads to the most revolutionary ideas in practice, is to compare the actual net heating effect produced with the total heat used to produce it. To make a comparison, one steam boiler may be 50 per cent. more efficient than another, in regard to coal used per ton of water vaporized, and a third 20 per cent. still more efficient; yet when we learn that these three boilers only return 30, 45 and 54 per cent. of the heating power of the coal, as heat in dry steam, we realize that there is still considerable room for improvement. In short, comparisons of general efficiency are only relative, while the calculation of net thermal efficiency

gives absolute data which are of the highest scientific interest and practical importance.

We must distinguish rather sharply, however, between two classes of operations, which do not allow of the application of the same standards of efficiency. These are (1) those requiring a definite amount of thermal effect to be produced, independent of the time, and (2) those which require the application of a certain temperature for a given time. We will explain more at length.

In operations of class (1) we wish to bring a substance into a given condition by the application of heat, and the *time* factor is sub-ordinate or negligible, the principal or controlling factor being the net amount of heat *absorbed* in the operation. In operations of class (2), the material usually absorbs some heat in being brought up to working temperature (and this part of the operation is identical with the whole of an operation of class 1) but here the material must be kept at this temperature for a shorter or longer period, simply for the physical changes which the temperature produces, and during this period no more heat is absorbed by it.

Thermal Efficiency (Class 1.)

The problem is, having a given substance or mixture of substances in a given physical or chemical condition, to apply heat so as to change it to a different physical or chemical condition, the said change absorbing a definite amount of heat energy in calories. Under such conditions, determine the thermal efficiency of the furnace. Here we must distinguish three cases: (A) when the desired change is merely one of temperature; (B) when the change is a mixed physical and chemical effect; (C) when the change is merely a chemical transposition.

(A) These form the simplest cases for determining thermal efficiency. Examples are as follows: The melting of metals or other substances for the purpose of casting them, the heating of metals to given temperatures for the purpose of working them, such as rolling, forging, etc.,—in short, all operations in which a substance is put into a furnace simply for the purpose of making it hot, or melting it, and then taken away from the furnace to be worked or used in the hot condition. In all these

cases, the thermal efficiency is simply the heat imparted to the body, divided by the total heat available in the furnace.

Illustration 1: An iron-foundry cupola melts 1000 kilograms of pig-iron by the use of 140 kilograms of coke, having a calorific power of 7000 Calories, and yields 980 kilograms of melted iron, ready for casting, containing 275 Calories per kilogram, there being oxidized 15 kilograms of iron and 5 of silicon. What is the thermal efficiency of the cupola?

Solution: The net useful effect is $980 \times 275 = 269{,}500$ Calories, which has been obtained from burning 140 kg. of coke, with a possible calorific power of 980,000 Calories, and the combustion of 15 kg. of iron and 5 kg. of silicon. The last two items afford

15 kg. Fe to FeO	$= 15 \times 1173 = 17{,}595$	Calories.
5 kg. Si to SiO^2	$= 5 \times 7000 = 35{,}000$	"
	52,595	"

which is in fact increased further by the heat of combination of 19 kg. of FeO formed with the 11 kg. of SiO^2, to form slag, amounting to

11×148	= 1,630	Calories
Total heat of oxidation	= 54,225	"
Calorific power of the coke..	= 980,000	"
Total heat available	=1,034,225	"

$$\text{Thermal efficiency} = \frac{269{,}500}{1{,}034{,}225} = 0.260 = 26.0 \text{ per cent.}$$

Illustration 2: 100 pounds of pure Swedish bar iron and 50 pounds of "washed" pig metal are put into a steel melting crucible and melted down in 2 hours, using 200 pounds of coke, to melted steel containing 315 Calories per unit of steel (pound Calories per pound). Assuming the calorific power of the coke 7000 Calories, what is the thermal efficiency?

SOLUTION: Heat in steel $150 \times 315 =$ 47,250 lb. Calories
Calorific power of the coke $200 \times 7000 = 1{,}400{,}000$ " "

$$\text{Thermal efficiency} = \frac{47{,}250}{1{,}400{,}000} = 0.0337 = 3.37 \text{ per cent.}$$

Illustration 3: 1000 kilograms of pure Swedish bar iron and 500 kilograms of "washed" pig metal are put into the crucible of an electric melting furnace of the induction type, and are

melted down in one hour to melted steel containing 315 Calories per kilogram, by the expenditure of 1,000 kilowatts of current. What is the thermal efficiency?

SOLUTION: Heat in melted steel $1500 \times 315 = 472{,}500$ Calories.
Heat energy of 1 kilowatt second $= 0.2389$ "
" " " " hour $= 0.2389 \times 3600 = 860$ "
" " " 1000 " hours $= 860{,}000$ "

Thermal efficiency $= \frac{472{,}500}{860{,}000} = 0.55 = 55$ per cent.

Such calculations as the above require a knowledge of the calorific power of the fuel used, data for calculating other sources of heat, and the net heat in hot or melted metals,—data such as are given in some of the larger compilations of physico-chemical data, such as Landoldt-Bornstein-Meyerhoff's tables, or the author's "Metallurgical Calculations."

Illustration 4: A regenerative gas furnace heats ten tons of soft steel ingots to 1000° C., using 900 cubic meters of natural gas of the following composition:

Hydrogen, H^2	22.50	per cent.
Methane, CH^4	60.27	" "
Ethylene, C^2H^4	6.80	" "
Carbon di-oxide, CO^2	2.28	" "
Oxygen, O^2	0.38	" "
Nitrogen N^2	7.32	" "

What is the thermal efficiency of the furnace?

Solution: Heat in the hot ingots at 1000° is 166 Calories per kilogram, according to Pionchon's (re-calculated) tests; therefore, to 10,000 kilograms of ingots there are furnished

$10{,}000 \times 166 = 1{,}660{,}000$ Calories.

Calorific power of the gas used per cubic meter:

Hydrogen	$0.2250 \times$	$2{,}613 =$	588	Calories
Methane	$0.6027 \times$	$8{,}598 =$	5182	"
Ethylene	$0.0680 \times$	$14{,}480 =$	985	"
Total			6755	"
per 900 cubic meters			6,079,500	"

Thermal efficiency $= \frac{1{,}660{,}000}{6{,}079{,}500} = 0.273 = 27.3$ per cent.

Examples could be multiplied almost indefinitely, from the metallurgical and metal-working industries, illustrating the applications of the above principles. They will be found es-

pecially valuable as indicating to the furnace designer and user the considerable room for improvement in thermal efficiency almost universally prevalent.

(B) When a considerable chemical change takes place in the mixture being heated, in order to get a hot product for casting or other hot-working, the heat absorbed or evolved in the chemical reactions must be also counted in. Such cases occur when melted metals are produced from the reaction of metallic ingredients. For example, pure (washed) pig-iron may be put into a crucible with enough pure magnetic iron oxide to burn out its carbon and produce steel. The heat in the resulting steel plus the heat absorbed in the chemical reaction is here the total useful calorific effect, and is to be compared with the calorific power of the fuel consumed.

Illustration 5: A charge put into a hot crucible consists of 100 pounds of "washed" pig-iron, containing 3.5 per cent. of carbon, and 13 pounds of pure magnetite concentrates, Fe^3O^4. Assuming the oxygen of the magnetite to form CO with part of the carbon of the pig-iron; that the steel resulting contains 315 lb. Calories per pound, and that 200 pounds of coke having a calorific power of 7,000 Calories is used, what is the thermal efficiency of the operation?

Solution: Oxygen in 13 pounds of Fe^3O^4

$13 \times (64 \div 232) = 3.59$ pounds.

Carbon consumed $3.59 \times (12 \div 16) = 2.69$ "

Carbon remaining $3.50 - 2.69 = 0.81$ "

Weight of steel:

$$96.5 + 0.81 + (13 - 3.59) = 106.72 \text{ pounds.}$$

Heat in melted steel:

$$106.72 \times 315 = 33{,}617 \text{ Calories}$$

Heat absorbed in chemical reactions:

De-oxidation of iron	$9.41 \times 1612 = 15{,}169$	Calories	(absorbed)
Oxidation of carbon	$2.69 \times 2430 = 6{,}537$	"	(evolved)
	Net $= 8{,}632$	"	(absorbed)
Total heat absorbed	$= 42{,}249$	"	

Heating power of coke $200 \times 7{,}000 = 1{,}400{,}000$ Calories.

Thermal efficiency $= \frac{42{,}249}{1{,}400{,}000} = 0.030 = 3.0$ per cent.

Illustration 6: Fifty metric tons (50,000 kg.) of pig-iron containing 3.5 per cent. of carbon, 2 per cent. silicon, and 1 per

cent. manganese is run into an open-hearth furnace, at 1250° C. As its temperature is being raised, red hematite ore is put in to oxidize out its impurities, a corresponding amount of iron being reduced. Heat in the pig-iron 275 Calories, in the finished bath (0.10 per cent. carbon), 350 Calories, per kg. During the heating 6,000 kilos of coal (calorific power 8500 Calories) are used in the producers. What is the net thermal efficiency of the whole plant (producers and furnace considered together)?

Solution: Oxygen needed from added ore:

Carbon 1,700 kg. $\times (16 \div 12)$	$=2{,}267$ kg.
Silicon 1,000 kg. $\times (32 \div 28)$	$=1{,}143$ "
Manganese 500 kg. $\times (16 \div 55)$	$= 145$ "
Total	$=3{,}555$ "
Ore required $= 3.555 \times (160 \div 48)$	$= 11{,}850$ kg.
Fe in ore $= 11{,}850 - 3{,}555$	$= 8{,}295$ "

Final weight of bath:

$$50{,}000 - (1{,}700 + 1{,}000 + 500) + 8{,}295 \text{ "}$$
$$= 55{,}095 \text{ "}$$

Heat in original pig iron $= 50{,}000 \times 275$	$= 13{,}750{,}000$ Cal.
Heat in final bath $= 55{,}095 \times 350$	$= 19{,}283{,}250$ "
Heat furnished	$= 6{,}533{,}250$ "

Heat absorbed in chemical reactions:

De-oxidation of iron $= 8{,}295 \times 1{,}746$	$=14{,}483{,}000$ Cal.	(Absorbed).
Oxidation of carbon $= 1{,}700 \times 2{,}430$	$= 4{,}131{,}000$ "	(Evolved).
" silicon $= 1{,}000 \times 7{,}000$	$= 7{,}000{,}000$ "	"
" manganese $= 500 \times 1{,}653$	$= 826{,}500$ "	"
Net heat absorbed	$= 2{,}525{,}500$ "	
Total thermal effect of furnace	$= 9{,}058{,}750$ "	
Heating power of coal used	$=51{,}000{,}000$ "	

Thermal efficiency of combined producer and furnace:

$$\frac{9{,}058{,}750}{51{,}000{,}000} = 0.177 = 17.7 \text{ per cent.}$$

(C) If the furnace is merely intended to accomplish a chemical transposition, and the heat in the final product is not a desideratum, but is capable of being utilized for return to the furnace, then the net heat absorbed in the chemical reactions is the only net thermal work accomplished by the furnace.

This is so, because the energy absorbed chemically must be furnished, but the heat carried out by hot products may be more or less perfectly returned to the furnace, i. e., is not final or definitive loss.

A blast furnace reducing iron ore, for instance, reduces the ore by means of carbon, or carbon monoxide, whereby a large amount of chemical work is accomplished. The product is liquid pig-iron, but its sensible heat is in no wise all a necessary loss—a large part of it might concievably be returned to the furnace as heat in hot blast. Similarly the slag carries out much heat, but some copper blast furnaces already use hot slag for heating their blast, so that this heat is not all a necessary loss. The gases pass out of the furnace hot, and with considerable calorific power, but their sensible heat can be utilized as well as their heat of combustion, for heating blast. Much heat is lost by radiation, but how much of this can be prevented is an unsettled question. In short, some inventor with ideas of economy, might well devise schemes for returning to the furnace a large proportion of the heat ordinarily lost by hot pig-iron, slag, gases and radiation, and the more he succeeded the more efficient his furnace would be, but the irreducible minimum, the absolutely requisite energy required for the chemical reactions, would always remain as the necessary measure of the useful thermal effect of the furnace.

Illustration 7: A blast-furnace produces pig-iron containing 3.5 per cent. of carbon, 2 per cent. of silicon and 1 per cent. of manganese, from red hematite ore, using 1 ton of coke (90 per cent. carbon, calorific power 7,000 Calories) per ton of pig-iron produced. What is the net thermal efficiency?

Solution: Letting the ton be 1000 kilograms, the coke contains 900 kg. of carbon, of which, however, 35 are necessarily required to go into the pig-iron, cutting down the available calorific power of the coke to 865/900 of its theoretical power. The heating power available is therefore:

$$7{,}000 \times 865/900 \times 1{,}000 = 6{,}728{,}000 \text{ Cal.}$$

Heat used in reductions:

Silicon	20 kg. $\times$ 7,000 =	140,000	
Manganese	10 kg. $\times$ 1,653 =	16,530	
Iron	935 kg. $\times$ 1,746 =	1,652,510	1,809,040 "

$$\text{Thermal efficiency} = \frac{1{,}809{,}040}{6{,}728{,}000} = 0.269 = 26.9 \text{ per cent.}$$

In the above calculation a few refinements have been left out, such as the heat of formation of the slag, which is positive, but usually balanced approximately by the heat required to decompose the flux. Many metallurgists are accustomed to regard the heat in slag and pig-iron as usefully applied heat, but when we consider that this heat may be utilized more or less, and if returned to the furnace would increase the net efficiency of the furnace, we see that it would be illogical to regard it as usefully applied heat. Any loss of heat which may be indefinitely reduced, or any heat, otherwise lost, which can be returned to the furnace, is not net useful thermal work.

Thermal Efficiency (Class 2.)

The second class of operations, which do not admit of calculations of absolute thermal efficiency, are those in which a furnace is kept up to heat for an indefinite time, during which physical or chemical changes take place in the contents of the furnace. Here only relative thermal efficiencies, of one furnace to another, can be calculated. The bases for making these comparisons are either (1) the calorfic power expended to keep a given working space (cubical content of the laboratory of the furnace) at a given temperature for unit of time, or (2) the calorific power used to keep a given quantity of material at a given temperature for unit of time.

If the problem is, for instance, to keep a core-oven up to a certain temperature constantly, the fuel necessary to do so, per day, can be best calculated per cubic foot or cubic meter of useful baking space, and thus two ovens compared with each other. If, again, the question is to keep a pot full of metal melted all day, at a certain temperature, while it is being cast, let us say, into small ingots, then the fuel consumed should be calculated per unit of time and per unit of metal kept melted; thus comparisons can be instituted, but no calculations of absolute net thermal efficiency are possible.

It might be thought that in cases such as those just cited a quantity analogous to net thermal effect might be obtained by suddenly drawing the fire and determining the rate at which the melted metal cooled. Multiplying its fall of temperature per minute by its weight and specific heat, a value is obtained representing the heat which the bath must have been receiving

per minute in order to keep it constantly at the required temperature, and therefore the net thermal effect produced per minute by the furnace. But this quantity is not an irreducible minimum, representing net thermal effect, for by putting a thicker non-conducting lid on the pot, the bath would cool much slower, and therefore we would be led to say that the net thermal effect was smaller, whereas the relative effectiveness of the furnace would be thereby increased.

This class of operations cannot be solved by the device of Mr. Queneau, who in his recent book on "Industrial Furnaces" says that the efficiency is to be measured by the ratio of heat radiated by the body of the furnace to the total heating power of the fuel. If that were so, very thin walls, which would increase greatly the heat radiated by the body of the furnace, would increase the efficiency of the furnace (!)

ECONOMIC EFFICIENCY.

This most general aspect of efficiency is a complex quantity; for, granted that the work is properly done, the cost of operation is composed of the following factors:

(a) Cost of fuel.
(b) Cost of repairs.
(c) Cost of labor and superintendence.
(d) Cost of power, light and general supplies.
(e) Depreciation.
(f) Interest on first cost.
(g) Interest on value of material being treated.
(h) Rent of necessary ground and building.

We will consider these items *seriatim.*

(a) If a furnace is run continuously the fuel required per unit of time, or if run discontinuously, the fuel required for unit of charge treated, might equally well be supposed to measure the efficiency of the furnace in regard to fuel. The proper basis of comparison, however, between two furnaces must be on the basis of unit amount of material treated or of useful effect produced. Here we must distinguish between the cost of the fuel and the quantity of the fuel. One furnace may need 1 ton of $5.00 coke to smelt 10 tons of ore, while another may use 1½ tons of $2.50 coal to do the same work, and the latter be therefore the most efficient of the two, in re-

gard to cost of fuel. The water-jacketted copper blast furnace and the rival reverberatory smelter will well illustrate this point. If two furnaces can use the same fuel, the weights used by each in doing a given work can measure their relative fuel efficiencies.

(b) The cost of repairs per year divided by the tonnage treated per year, yields a figure which is often highly important in determining the efficiency of a furnace. Many moving parts, poor design, too light construction, too heavy walls, too expensive machine work to replace if broken, will all count in making a heavy repair bill. This item of repairs per unit of output should be distributed over a considerable period, so as to cover all kinds of periodically-occurring stoppages due to general inefficiency of the furnace.

(c) Labor forms often the largest single item in the expense account. Two furnaces may accomplish almost exactly similar results, and yet one require twice or even more laborers than the other, or one require highly skilled (and therefore high-priced) attention, while the other requires only moderately skilled labor in order to do just as good work. One of the chief items of economy in modern metallurgical practice is the great increase in the size of furnaces, by which the labor expense per unit of product is almost invariably greatly reduced, —in some cases to a small fraction of its former cost. If one highly-skilled superintendent controls the manufacture of 1000 tons of steel per day, at a yearly salary of $5000, the cost of this skilled attention is much less per ton of steel than in a mill where a $2000 man superintends the production of 200 tons daily. Such economies are possible, where, for instance, the first plant possesses 20 50-ton furnaces, and the second 20 10-ton furnaces.

(d) Two furnaces may do equally good work, with the same fuel and cost of repairs, labor and superintendence, and yet cost very differently as requires motive power, light and other supplies, such as oil, belt grease, etc. These all have their bearing on the efficiency of the furnace.

(e) Although constant repairing will keep a furnace together for a long while, yet a time comes sooner or later when it has to be practically rebuilt. Foundations will eventually sink, buck-staves rust where embedded in the ground, the hearth

get past repairing, and the roof *hors du combat*. This general re-building may come once in five years or once in fifteen, but the oftener it does come the less efficient the furnace must be regarded. Charging as depreciation 5 to 20 per cent. per year, on the first cost of the furnace, according to the life of the furnace, and dividing by the tonnage per year, there is obtained the proper depreciation cost per ton of output.

(f) Interest on cost of the furnace, at say six per cent. a year, is a proper charge, because of two furnaces doing equally good work, that one is most efficient which cost the least; and the only way to properly enter this item in the comparison of the two furnaces is to charge the interest cost per ton of material treated. Expensive castings or machine work, high-priced linings or special shapes of bricks, deep excavations, or high chimneys, all add greatly to first cost, and entail high capital charges.

(g) Two furnaces may do work of equally good quality, and turn out practically the same average output per day, and yet one furnace may keep the material in course of treatment only an hour, another a week. Or, putting it another way, one furnace may contain in course of treatment, ten tons of material and another one hundred tons, and yet the average daily output and working charges be the same per ton for each. In such cases, an interest charge on the material under treatment is a proper item in the cost sheet, in order to get a numerical expression for this difference of efficiency of the two furnaces. An ordinary 50-ton open-hearth furnace turns out 100 tons of steel per day; a Talbot continuous furnace turning out the same amount has 200 tons of steel under treatment continuously, so that the interest charge on material under treatment would be twice as great in the second case as in the first. An ordinary reverberatory roasting furnace will turn out say ten tons of roasted ore per day, the ore not being in the furnace over 24 hours; roasting stalls to roast 150 tons in 15 days (an average of ten tons per day) require that the ore be under treatment 15 days. The interest charges on value of ore under treatment is fifteen times as heavy for the stalls as for the reverberatory furnace; and in this regard the latter is much the more efficient style of roasting furnace. Smelters of the more valuable metals, particularly of copper, silver and gold, pay

particular attention to these interest charges, as they sometimes are the main factors in the total efficiency of the furnaces used.

(h) The necessary ground space and building for housing a furnace is often very different for two furnaces of the same output. Where space is at a premium, it is important that a furnace occupy small ground space, and the more compact furnace is the most efficient in this respect. A Stetefeldt furnace for chloridising roasting of silver ores will, for example, roast 80 tons in 24 hours, and occupy a space of 55 square meters; while reverberatory furnaces for the same output would occupy 700 square meters, and need a building of that size to cover them. It is correct, therefore, to add the rent of necessary ground, or ground and building, calculated per ton of output, to the cost sheet, in order to properly compare the efficiencies of furnaces.

(i) To all the above items should be added a term which cannot be expressed in dollars and cents, but only in words; viz., general reliability. The furnace which does the most uniform work, with the least brain fag for the superintendent, and which can be counted on as always doing its work, is preferable, and usually preferred, to the one which may do its work a little more cheaply but is not so reliable.

PRODUCTION OF BISMUTH IN 1905.

The marketed production of bismuth ore in 1905 was 24,405 pounds, valued at $4,187; in 1904 it was 5184 pounds, valued at $314. There was no marketed production of bismuth ores in the United States during 1903 or 1902. Interesting features in the bismuth industry in 1905 were the shipment of ore from a new deposit in California, the resumption of mining on the Ballard property in Colorado, and the reduction of 50 per cent. in the price of the metal in London from 10 s. ($2.43) to 5 s. ($1.22) a pound.

PRODUCTION OF ZINC IN 1905.

The production of zinc in 1905 showed an increase in quantity as compared with 1904, 1903, 1902 and 1901, the production being 203,849 short tons, as compared with 186,702 short tons in 1904, with 159,219 short tons in 1903, with 156,927 short tons in 1902, and with 140,822 short tons in 1901. The value of the zinc production in 1905 was $24,054,182, as compared with $18,670,200 in 1904, with $16,717,995 in 1903, with $14,625,596 in 1902, and with $11,265,760 in 1901.

ELECTRICAL SECTION.

(Stated meeting held Thursday, December 27th, 1906.)

The First Atlantic Telegraph Cable.*

By John Mullaly.

September 1, 1858, was an eventful day in the municipal history of New York, for on that day the city celebrated the landing of the first Atlantic Telegraph Cable, by which the long-talked of and eagerly-desired electric communication was effected between America and Europe, between the New World and the Old.

The popular enthusiasm, which had been increasing from day to day, after the wondrous tidings had reached New York and had been flashed over the wires to the utmost boundaries of the Republic, that "the Impracticable Enterprise," as it was stigmatized, had become a reality, culminated in one of the grandest of popular demonstrations that had ever taken place in the Empire City. All classes united in the celebration. As for the press it surpassed all previous efforts. It was indefatigable in the collection of the minutest items, and its headlines were marvels of composition and typographical display. Thus it was announced, in the biggest of capitals, that "the Cable Carnival" had attracted "Half a Million of Visitors from Afar and Near,"—a vast multitude for that day;—that the "Metropolis was literally overwhelmed with the huge crowds;" that the celebration was a "Glorious Recognition of the Most Glorious Work of the Age;" and so-forth through the column or more following the laudatory captions.

As to the public procession, the metropolis never saw anything comparable with it before. It was the largest, the most

*Read by title.

varied and the most picturesque. The civic and military authorities co-operated in the work of organization, in which the public participated heart and soul, all the associations, trade societies, clubs and kindred bodies contributing their efforts to make the celebration in every way worthy of the occasion. In the line the place of honor was, of course, given to the officers and crews of the Telegraph Squadron. At night the city was illuminated and the City Hall, which was almost hidden under a profusion of banners and flags and streamers and bunting, fashioned into folds and festoons of every conceivable form, glowed with the light of thousands of gas jets and colored lamps. Conspicuous among the distinguished persons in the procession besides the Mayor and other chief officials of the municipality, were Mr. Cyrus W. Field, Professor Morse, the inventor of the electro-magnetic telegraph; Captain Hudson, of the U. S. Steam Frigate Niagara, and the captains of the two British ships, the Valorous and the Gorgon, which, after the landing of the cable, accompanied our vessel from Newfoundland to New York.

In addition to the illumination there was a torchlight procession of the firemen, with their massive hand-engines, hose-carts and ladder trucks, making one of the most striking, as it always was one of the most popular, features in all public demonstrations. The shipping in the harbor presented an animated spectacle with its endless array of flags and streamers of all sizes and colors, among which could be distinguished the national emblems of nearly every maritime power.

The celebration, however, was not limited to the outdoor display, for there were few associations, or clubs, or other organizations of note that did not manifest their appreciation of the event by some special festivity or entertainment. The grand municipal banquet, at which the guests were numbered by thousands, and which took place in the Crystal Palace, then occupying the site now known as Bryant Park, fittingly closed the celebration of this historic episode.

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From the 5th of August, 1858, the day on which the cable was landed, to that on which the celebration took place, numerous dispatches had been transmitted through the line from

the two stations, among which were those conveying the congratulations of Queen Victoria and President Buchanan on the accomplishment of the work by the ships of the two nations. According to the official report the total number of messages sent from station to station was three hundred and sixty-six, of more or less importance. Hardly, however, had four weeks elapsed before the electrical connection had ceased altogether; the defects which had been the cause of the many delays and difficulties encountered on the different expeditions having not only impaired, but finally destroyed the continuity.

But, notwithstanding the failure of the first cable, the important fact that the paying-out process was a mechanical success and that a machine had been devised and constructed that had proved equal to the task, inspired the company with such confidence that the required amount necessary for the renewal and prosecution of the enterprise in 1866 was ultimately secured and another and more efficient cable was laid. For this renewal of the work the company was indebted mainly to the one man, Cyrus W. Field, who throughout the whole history of the enterprise was its guiding spirit. His indomitable energy and resolution overcame all obstacles, and he manifested his absolute faith in the great project by subscribing $500,000 of the original capital of $1,750,000. Among the principal American subscribers to the stock besides Mr. Field, were Mr. Peter Cooper, Mr. Chandler White, Mr. Marshall O. Roberts, Mr. Moses Taylor and Archbishop Hughes.

The first cable, as stated, had not only ceased to work, but every attempt to raise it proved futile, and it was finally abandoned.

The writer of this article had the good fortune of participating in the first Atlantic Telegraph Expeditions, those of 1857 and 1858. In 1857 he held the temporary position of secretary to Professor Morse, and the following year acted in the same official capacity to Mr. Field, Mr. Morse not taking an active part in the subsequent operations and therefore not present on the last expedition. In these relations, as well as through being the guest of the officers of the Niagara during the several expeditions, covering altogether a whole year, he had unusual opportunities and advantages for obtaining infor-

mation of the most accurate and reliable character in regard to the enterprise and the details of the work.

The following account of the first Atlantic Telegraph Expeditions can therefore be relied upon as being from the pen of an eye-witness who was personally cognizant of all he has described:

A company was organized in the month of March, 1852, under the title of the "Newfoundland Electric Telegraph Company," for the purpose of establishing communication between Europe and America. The manner in which it was to be accomplished was through a line of telegraph constructed across the southern part of Newfoundland extending from Cape Race at its eastern extremity to Cape Ray at its western, and connecting Cape Ray with Cape Breton by a submarine cable across the Gulf of St. Lawrence. The telegraphic communication with the United States was to be effected by a line from Cape Breton to Prince Edward Island, across the strait which divides that island from the mainland to New Brunswick, and thence on to the United States through the various telegraph lines and connections already established. Such, in brief, was the plan by which it was proposed to connect St. Johns with all parts of this country and the British Provinces. The communication with Europe was to be completed by the steamers that plied, or were to ply, between Great Britain and the United States.

But the company by which all this was to be accomplished was unable, for want of that wherewithal without which neither the great nor the petty affairs of the world can be transacted, to carry out their designs. Their resources were unequal to the undertaking, and after a long but ineffectual struggle they sank into hopeless bankruptcy. True, they had a charter, but they were unable to fulfil its obligations, or meet its requirements, and thus lost all the privileges and grants which were to be conferred on the successful termination of the project. Under these circumstances application was made to Mr. Matthew D. Field, and through him to his brothers, Mr. Cyrus W. and Mr. David Dudley Field, to carry on the work which the insolvent company was obliged to abandon.

Both these gentlemen took the subject into earnest consideration, and Mr. Cyrus W. Field, who had in view the sub-

merging of a cable between Ireland and Newfoundland, wrote to Professor Morse and to Lieutenant Maury, Superintendent of the National Observatory, and author of "The Physical Geography of the Sea," in regard to the practicability of the undertaking. From the first of these distinguished scientists he received the most satisfactory and encouraging assurances in regard to the electrical character of the enterprise; and Lieutenant Maury's reply in relation to the nautical part was no less gratifying and hopeful.

Thus assured by the highest authority, the great task was commenced, and though the man to whose energy and tenacity of purpose the world is mainly indebted for the success of the enterprise was fully aware of the almost insuperable difficulties he would have to encounter, he entered upon it with a determination that overcame all obstacles.

A new company, however, had to be organized and a new charter obtained before they could enter on the practical part of the undertaking; it was, therefore, decided to solicit the cooperation of capitalists whose resources and financial ability would be equal to the magnitude of the work and whose reputation would constitute the best evidence and the most substantial proof of their earnestness and sincerity of purpose. This was regarded as of the first importance to inspire the public with the desired confidence in the integrity of the company. Such co-operators Mr. Field found in Mr. Peter Cooper, Mr. Moses Taylor, Mr. Marshall O. Roberts and Mr. Chandler White. The plans and prospects of the organization were laid before these gentlemen and discussed at four successive meetings in the residence of Mr. Field, and it was finally resolved that a committee of three, consisting of Mr. Cyrus W. Field, his brother, Mr. David Dudley Field, and Mr. Chandler White (who died before the completion of the work of which he had been not only an enthusiastic but efficient advocate) should proceed at once to Newfoundland and procure a charter from the Government of that Colony. As a preliminary step, however, the new company paid off the debts of the old, amounting to about fifty thousand dollars, purchased all its property and in return received the charter under which that company was incorporated.

The agreement by which the Electric Telegraph Company

surrendered their rights was signed on the 10th of March, 1854, and four days after the Committee of Three started for St. John's, Newfoundland.

It is not necessary, for the purposes of this narrative, to enter into particulars regarding the progress and results of their mission; it is sufficient to know that they were cordially welcomed, and their application was as promptly entertained and acted on by the colonial authorities as the nature of the case would permit. The most liberal and generous spirit was manifested in the granting not only of the rights and privileges specified in the charter, but in the substantial and valuable concession of lands and subsidies, including the exclusive right of landing telegraph lines on the shores of the island and other lands within their jurisdiction, comprising, in addition to those of Newfoundland, the whole Atlantic coast of Labrador from the entrance of Hudson's Straits to the Straits of Belle Isle. The company also obtained in May, 1854, an exclusive charter from the Government of Prince Edward's Island, and afterwards from the State of Maine, and a charter for telegraph operations in Canada.

Thus far the efforts of the New York, Newfoundland and London Telegraph Company had been successful and the prospects were very promising, but the practical part of the work was still untouched and as it came to be contemplated in all its vast proportions, filling the minds of its projectors with the uncertainties and anxieties of an untried problem, a problem which some scientists regarded as impossible of solution, it might well seem to the great multitude the impracticable scheme of mere enthusiasts and visionaries; or, if not worse, the insidious designs of corrupt speculators on the gullibility of a too confiding public.

But the men at the head of the enterprise had calmly considered the chances of success; they had measured the difficulties with which they would have to contend and regarded with hopeful minds the facilities which nature herself presented to encourage its prosecution. They had been told by the highest scientific authorities that at the bottom of the stormy ocean which lay between Ireland and Newfoundland, the two island outposts of the New and Old World that were to form the points of connection, there was a vast submarine plain, an

extended plateau, on which reigned the silence of the grave and the darkness of night, where the remains of minute forms of life, so minute as to be imperceptible to the unaided vision, had lain undisturbed for untold centuries; where currents were not, and where the storms that swept over the surface two miles above, and lashed the angry waters into foam, were unknown except by the wrecks and lifeless forms with which they strewed the depths. There, in the language of the inspired writer, was the path which "the bird hath not known, neither hath the eye of the vulture beheld it, the children of the merchant have not trodden, neither hath the lioness passed by it." There the cable might lay undisturbed for centuries, and the only change would be that produced by those subtle chemical agencies which are never at rest, and which by the combination of the protecting iron with the corrosive elements of the sea, would enclose and surround it with a concrete mass, affording it a still better protection than it had received before from its outer wire covering.

What matter how much geologists may differ as to the causes which have produced this submarine plateau, this table land of the ocean, and who really cares whether it was built up by the disintegration of rocks borne down innumerable ages ago from Arctic mountains by gigantic icebergs, or by those infinitesimal shells which have been brought up from its surface by the sounding leads of Lieutenant Berryman and Captain Dayman, the two distinguished officers of the American and British Navies, who made the surveys under the orders of their respective governments. That is a question for further scientific research, and so it may be left. It is sufficient for us to be assured that it is the safest and best resting place for the cable.

On the 19th of July, 1856, Mr. Field sailed for England for the purpose of enlisting the aid of English capitalists, and in the course of three weeks, during which he had addressed large and influential meetings in Liverpool, Manchester and London, he obtained all the capital required. The organization of a corporation entitled the "Atlantic Telegraph Company" followed; and everything seemed to conspire in favor of the enterprise. Through the same indefatigable agent a contract was made with the Governments of Great Britain and the United States, by which both agreed to furnish ships for the

laying of the cable, and when that was done to pay an annual sum of seventy thousand dollars each for the transmission of official messages.

Everything was now ready for the mechanical part of the work. A cable connecting Cape Breton with Newfoundland had been laid across the Gulf of St. Lawrence, and the land line over the southern part of the latter island had been constructed. The great cable, itself, was not yet done, but the manufacturers at Birkenhead and Greenwich had promised to have it completed in time for the expedition, which was to sail in the summer of 1857.

(*To be continued.*)

Erratum.

(*Journal,* January, 1907, p. 33.)

Art: Hoge, Independent Telephone Development. For Fredericksdorf, near Hamburg, Germany, *read* Frederichsdorf, near Homburg vor der Hoehe, Germany, as the place where Philip Reis made his experiments with the telephone.

Sections.

ELECTRICAL SECTION.—Stated meeting held Thursday, November 8th, 8 o'clock. President Thomas Spencer in the chair. Present, sixteen members and visitors.

The paper of the evening was read by Albert F. Ganz, Professor of Electrical Engineering in Stevens Institute, on "The Physical Meaning of Power Factor and the Significance of a Power Factor Less than Unity without Phase Difference."

The paper was freely discussed. The speaker received a vote of thanks for his interesting communication and the meeting was adjourned.

RICH'D L. BINDER, *Secretary.*

Stated meeting held Thursday, November 22d, 1906. President Thomas Spencer in the chair. Present, forty-two members and visitors.

The paper of the evening was read by Mr. James B. Hoge, President of the International Independent Telephone Association of America, who spoke on "Independent Telephone Development."

The paper was discussed by Messrs. E. A. Scott, W. C. L. Eglin, H. F. Colvin and others.

The thanks of the meeting were voted to the speaker

Adjourned.

WM. H. WAHL, *Sec'y pro tem.*

SECTION OF PHOTOGRAPHY AND MICROSCOPY. The 40th meeting of the Section was held on Thursday, December 6th, at 8 P.M. Dr. Henry Leffman in the chair. Present, twenty members and visitors.

The first communication of the evening was read by Mr. J. W. Ridpath on "Pictorial Composition for Beginners in Photography."

The author gave an interesting resumé of the points necessary for pictorial composition, and illustrated his remarks by the exhibition of a number of characteristic lantern views.

Mr. U. C. Wanner exhibited and commented on a number of interesting pictures of animal studies and described the method of making the same.

The thanks of the meeting were voted to the speakers. Adjourned.

M. I. WILBERT, *Sec'y.*

MECHANICAL AND ENGINEERING SECTION. *Stated Meeting*, held Thursday, December 13th, at 8 o'clock P.M. Mr. Chas. Day, President, in the chair. Present, twenty-five members.

The paper of the evening was read by Mr. Henric V. von Z. Loss, M.E., member of the Section, on "The Art of Manufacture of Railway Car Axles."

Mr. Loss took up in detail the various methods which have come into commercial use for the manufacture of railway axles, and some of the improved methods which have been tried from time to time, and then described and illustrated by a model a forging press for producing axles. This press operated on the well known principle which Mr. Loss has used in his I-bar forging process.

The paper was discussed by Messrs. Christie, Colvin, Church, Hunsberger, Derbyshire and the author.

On Mr. Christie's motion, duly seconded, the subject was referred to the Committee on Science and the Arts for investigation and report.

The meeting passed a vote of thanks to the speaker of the evening, and was adjourned.

FRANCIS HEAD, *Sec'y.*

MINING AND METALLURGICAL SECTION. A regular meeting of the Section was held on Thursday, December 20th, at 8 P.M. Mr. James Christie in the chair.

The paper of the evening was read by Prof. Joseph W. Richards, of Lehigh University, on "Furnace Efficiencies."

It was freely discussed by Messrs. Carl Hernig, C. J. Reed, James Christie, the author and others, and is referred for publication.

The speaker received the thanks of the meeting for his able and interesting presentation of the subject, and the session was adjourned.

W. J. WILLIAMS, *Sec'y pro tem.*

Book Notices.

Annuaire pour l'an 1907 publié par le Bureau des Longitudes avec des notices scientifiques: Paris, Gauthier-Villars, n. d. 900 pages, illustrations, 16mo., paper. Price, postage paid, 1 franc, 85c.

The little book contains much information which is useful to the engineer and man of science. The special articles of the present issue are by M. A. Bouquet de la Grye on the diameter of Venus and M. H. Deslandres on the history of conceptions and of the researches regarding the sun.

Self-propelled Vehicles: A practical treatise on all forms of automobiles, by James E. Homans, A.M. Fifth revised edition, entirely re-written. 598 pages, illustrations, plates, 8vo. New York, Theo. Audel & Co. 1907. Price, $2.00.

New and completely revised, this work fulfills the requirements of the motor vehicle owner, operator and repairer. In his revision the author has emphasized the practical aspects of motor vehicles of all powers, confining his space to the discussion of matters fundamental in construction and management. Recognizing that the gasoline vehicle is the typical automobile, considerable space is devoted to its complete discussion, theory, operation, and an extensive chapter on "Gasoline Engine Management," the latter covering, virtually, all forms of difficulty liable to occur under service conditions.

All the accessory parts of an automobile, carburetters, igniters, transmission gears, are fully explained by typical examples. The author properly assumes that an adequate knowledge of the principles upon which these devices are constructed will enable the reader to understand variations for himself.

Second Report of the Wellcome Research Laboratories at the Gordon Memorial College, Khartoum. Andrew Balfour, M.D., B Sc. Khartoum, Department of Education, Sudan Government, 1906. 255 pages, illustrations, colored plates, 4to.

The present report gives an outline of the progress made in dealing with malaria, sleeping sickness and the various other tropical diseases in the Sudan. There are also a number of original articles on the insect pests which attack food and textile-producing plant life. The numerous illustrations, especially the full-page plates of flies, in colors, are excellent.

Penrose's Pictorial Annual: The Process Year Book for 1906-7. Vol. 12. Edited by William Gamble. 160 pages, illustrations, 8vo. London, A. W. Penrose & Co., Ltd. American Agents, Tennant & Ward, New York. Price, $2.50.

For twelve years this popular annual has been making its appearance. Each year it grows in size and in value. All who are interested in any way in the graphic arts will find this work useful.

There are many excellent examples of half-tones, two- and three-color prints, collotypes, line etchings and photogravures. The reading matter is as varied and interesting as heretofore.

PUBLICATIONS RECEIVED.

Otis Elevator Company. Catalogue illustrating and describing, in general, elevating machinery and apparatus. 62 pages, illustrations, 8vo. New York, 1905.

Life Insurance: The Abuses and the Remedies. An address delivered before the Commercial Club of Boston, by Louis D. Brandies. 27 pages, 8vo. Boston, Policy-Holders Protective Committee, 1905.

Nature Study and Gardening. Primary methods and outlines for the use of teachers in the Indiana Schools. 27 pages, illustrations, plates, 8vo. Washington, Government Printing Office, 1905.

Philippine Journal of Science, Vol. I. No. 1, January, 1906. Edited by Paul C. Freer, M.D., Ph.D. Co-Editors, Richard P. Strong, M.D., and H. S. McCackey, B.S. Published by the Bureau of Science of the Government of the Philippine Islands. Manila, Bureau of Printing, 1906. Contents: Papers on the Cocoanut Palm and the Cocoanut, by Paul C. Freer, Edwin Bingham Copeland and Herbert S. Walker; The Occurrence of Schistosoma Japonicum vel Cottoi in the Philippine Islands, by Paul G. Woolley; A Study of some Tropical Ulcerations of the Skin, with Reference to their Etiology, by Richard P. Strong. 115 pages, illustrations, plates, 8vo.

Annual Report of the Secretary of the Navy for the year 1905. 54 pages, 8vo. Washington, Government Printing Office, 1905.

Report of the Chief of the Bureau of Ordinance to the Secretary of the Navy, 1905. 48 pages, 8vo Washington, Government Printing Office, 1905

Tonindustrie Kalender, 1906. Three parts, illustrations, 24 mo. Berlin, Verlag der Tonindustrie Zeitung.

Doble tangential water wheels, Doble patented needle regulating nozzles, Doble patented ellipsoidal buckets, Doble high-speed ring-oiling bearings, manufacturd by Abner Doble Company, engineers, San Francisco. Bulletin No. 7, 1906. 100 pages, illustrations, 8vo.

U. S. Coast and Geodetic Survey, Terrestrial Magnetism. Results of magnetic observations made by the Coast and Geodetic Survey between July 1, 1904, and June 30, 1905, by L. A. Bauer,, inspector of magnetic work. Appendix No. 3, Report for 1905. 85 pages, 4to. Washington, Government Printing Office, 1905.

Teachers' Sanitaty Bulletin, published monthly by the State Board of Health, Lansing, Michigan. Volume 8, Nos. 7, 8, 9, July, August, September, 1905.

Report of the Superintendent of Indian Schools to the Commissioner of Indian Affairs for the year ending June 30, 1905. 34 pages, plates, 8vo. Washington, Government Printing Office, 1905.

Koenigliches Materialpruefungsamt der Technischen, Hochschule, Berlin. Bericht ueber die Taetigkeit im Betriebsjahre, 1904.

Sonderabdruck aus den Mitteilungen aus dem Koeniglichen Materialpruefungsamt Gross-Lichterfelde West, 1905. 50 pages, 8vo.

The Irrigation System of Ontario, California, its development and cost, by F. E. Trask, with discussion by Messrs. Arthur S. Hobby and F. E. Trask. Reprinted from the Transactions of the American Society of Civil Engineers, Vol. 55, page 173. 10 pages, illustrations, plates, 8vo. Issued by the Abner Doble Co., San Francisco, Cal., as Bulletin No. 9.

The Franklin Institute.

(Proceedings of the Annual Meeting held Wednesday, January 16th, 1907.)

HALL OF THE INSTITUTE,

PHILADELPHIA, PA., January 16th, 1907.

PRESIDENT JOHN BIRKINBINE in the chair.

Present, twenty-three members.

The Annual Reports of the Board of Managers and of the various Committees of the Institute and the Board. Also the Annual Report of the Trustees of the Elliott Cresson Medal Fund were presented and accepted, and directed to be published.

The tellers of the Annual Election made their report showing the election of all the candidates nominated at the stated meeting of December 19, 1906. The President thereupon declared the nominees duly elected to their respective offices. The tellers received a vote of thanks.

President Birkinbine thereupon introduced Mr. F. H. Newell, of the U. S. Geological Survey, Washington, D. C., who presented a paper, profusely illustrated with lantern photographs, on "The Work of the Government Reclamation Service." In this communication, Mr. Newell gave a description of a number of the more important engineering works that had been executed and of a number at present under way, designed to reclaim, for the purposes of agriculture, many thousands of acres of arid and semi-arid lands in the far West.

The speaker received a vote of thanks.

The retiring President, Mr. Birkinbine, thereupon introduced President-elect Mr. Walton Clark, who, after expressing his appreciation of the honor conferred upon him, assured the members of his complete devotion to the promotion of the interests of the Institute.

Adjourned.

WM. H. WAHL, *Secretary.*

Report of the Board of Managers for the Year 1906, with Appendices Embracing the Annual Reports of Committees and Sections.

To the Members of the Franklin Institute:

The Board of Managers submit for your consideration this report and accompanying appendices covering the work of the Institute during its eighty-second year of usefulness.

During 1906 the two hundredth anniversary of the birth of Benjamin Franklin was celebrated in Philadelphia with impressive ceremonies, at which your President represented the Institute. Recognition of the anniversary was also made by the Institute in a series of special papers read at

the monthly meetings, and subsequently published in the *Journal*, which presented the life and works of Franklin in an instructive and interesting manner.

More pretentious ceremonies had been contemplated, but these were omitted so that the Franklin Institute should not appear as interfering with the commemorative functions outlined by the American Philosophical Society, which claims Franklin as its founder.

The Board also regrets that owing to the impossibility of securing the buildings, for the use of which arrangements were in progress at the last report, the exhibition suggested as a fitting celebration of the Franklin Bicentennial had to be abandoned.

During the year a special committee has succeeded in making progress towards securing for the Institute a new home, where in a more desirable location, and with improved facilities, it can keep pace with the progress of a great city and a great country. Upward of One Hundred Thousand Dollars have been pledged towards this object, and the committee is endeavoring to increase this fund to Two Hundred and Fifty Thousand Dollars. Chances for success will improve as subscriptions from members and friends grow in amount.

An appeal may properly be made to those who have benefitted by the Franklin Institute work, urging their assistance in securing funds to erect a new and well-equipped building which will be conveniently situated.

The report of the Library Committee shows that the Institute now has 60,248 volumes, and in addition pamphlets, maps, charts, etc., some of them unique, which make an aggregate of 109,263 titles, in fact, an unexcelled technical library which cannot be used to the best advantage because of the limited space and restricted income.

The report of the Committee on Instruction emphasizes existing conditions, under which the 598 pupils received instruction in the night schools of drawing, machine design, and naval architecture, and records the fact that owing to the limitations of our buildings some of the lecture courses have to be presented in conjunction with the Young Men's Christian Association in its Auditorium.

Ten meetings of the Institute and twenty-six sectional meetings, held during the year, were rich in contributions and discussions upon Physics, Chemistry, Electricity, Mining, Metallurgy, Engineering, Photography, Microscopy, and other specialties, many of which have appeared in the *Journal of the Franklin Institute*, our Institute publication, which has a world-wide reputation.

The Committee on Science and the Arts considered sixty-one applications for award, and granted during the year eleven medals and one certificate of merit. It also made three advisory reports and dismissed six applications.

When it is remembered that the labors of the members of this committee, as well as those of all the Institute and Board Committees, are gratuitous, that the services of most of the lecturers are given without compensation, and that such unselfish work has characterized the Franklin In-

stitute for eighty-two years, it would seem that the Institute's claim for support should meet a ready response.

The financial statement which exhibits the condition of the Institute also shows that the total endowment, including funds devoted to special purposes, aggregates $140,000, a sum far below what an organization should command to carry forward the work which the Institute should assume; in fact, the income from invested funds will not properly sustain the Library.

During the year an application has been made for the Uriah A. Boyden Premium of $1,000 to be awarded to one who shall demonstrate whether light and other physical rays are, or are not, transmitted with the same velocity. The application is being considered by a special committee.

Death removed during the year two members of the Board of Managers, Mr. R. C. H. Brock, who served from 1901 to 1906, and Mr. Samuel Sartain, who sat on the Board for forty-one consecutive years. Since 1882 he has been the Treasurer of the Institute. The *Journal* has published a fitting obituary of Mr. Brock, and a committee will prepare a suitable memorial of Mr Sartain, but it is eminently proper that this report should include a minute of the great service rendered the Institute by its late Treasurer.

The Board has properly acknowledged donations which have been made to the Institute, all of which are fully recorded in its minutes.

The membership roll now numbers 1,532, of which 830 are resident and 702 are non-resident members.

JOHN BIRKINBINE,
President.

PHILADELPHIA, PA., January 9, 1907.

FINANCIAL STATEMENT FOR 1906.

The annual report of the Treasurer for 1906 shows:

Balance January 1st, 1906	$ 653.70
Total receipts	33,452.79
	34,106.49
Total payments	33,700.42
Balance January 1st, 1907	$ 406.07

REPORT OF THE LIBRARY COMMITTEE FOR THE YEAR 1906.

To the President and Members of the Franklin Institute:

The Committee on Library respectfully submits the following report:

The additions to the Library during the year 1906 comprised 1,793 titles, as against 2,132 in the preceding year and 2,397 in 1904.

The new acquisitions include:

872 bound volumes,
285 unbound volumes,
566 pamphlets,
12 charts,

1 manuscript,
57 drawings,

These accretions were derived from the following sources:

71 through the Bloomfield Moore Fund,
2 " " Memorial Library Fund,
63 " " M. Carey Lea Fund,
17 " " James T. Morris Fund,
38 " " general library appropriations,
192 " " binding of periodicals,
47 " " *Journal* of the Institute,
34 " " exchange account,

and the remainder through deposits from the Federal and State Governments, through contributions from societies and institutions at home and abroad and through gifts from individual donors. Especially notable have been the contributions received from:

Drs. S. Solis Cohen and William H. Greene; Prof. Lewis M. Haupt; Mrs. Samuel C. Hooker, Mrs. Wilfred Lewis and Mrs. M. Russell Thayer; Messrs. H. M. B. Bary, John E. Carter, James S. Coates, George S. Cullen, Morris Ebert, Richard Gilpin, Henry Pemberton, Jr., Anthony W. Robinson, E. Smith, James M. Swank, and the Crocker-Wheeler Electric Company.

The pamphlet additions are again below the average, and it is due, as in former years, to the fewer gifts received from members. There is a slight increase in the number of volumes purchased during the year, though the Committee is still following out the policy of utilizing the various library funds for the purchase of large and more important reference works, which are naturally sought in the collection of a special technical library. It is in this direction that the Committee finds itself most hampered for the want of a greater income.

The present contents of the Library are as follows:

60,246 volumes (bound and unbound),
43,913 pamphlets,
2,886 maps and charts,
747 drawings and designs,
1,247 photographs,
192 newspaper clippings,
32 manuscripts,

a total of 109,263 titles.

There are also on hand at the present time the following number of duplicates: 449 bound volumes, 134 unbound volumes and 150 numbers of periodicals. These are not included in the permanent collections of the Library as they may be disposed of by exchange or otherwise.

BINDING.

Binding and re-binding were effected during the past year as follows:

191 volumes of complete serials,
203 paper-bound books,

24 rebindings,
1 repaired,

Four hundred and thirty-six volumes are still in the binder's hands. More binding is sadly needed, and more money could be spent on binding with great advantage to the Library. The British Patent Specifications especially should be bound, since, although these documents are accessible in their present condition, it is imperative that they should be bound if they are to be permanently preserved.

PAMPHLET COLLECTION.

The pamphlets of the Library are stored on shelves on the first floor of the building in the south room. They are safe enough there, but owing to lack of classification they are practically unavailable for use. Many of these pamphlets are exceedingly valuable, and in order that they may be available to students, they should be classified and appear in the card catalogue of the Library. This work will require the services of a trained assistant for several years and will necessitate the expenditure of a considerable sum of money for wages, catalogue cards, pamphlet boxes, and incidentals.

EVENING ATTENDANCE.

The Library was open on forty-four evenings during the past year, with a total attendance of 182 visitors, an increase of twenty-one over the preceding year. While it is to be hoped that the number of evening visitors will continue to increase, it is hardly likely that any great change will occur as long as the Institute is in the present quarters.

EDWIN S. BALCH, *Chairman.*

REPORT OF THE COMMITTEE ON SCIENCE AND THE ARTS FOR THE YEAR 1906.

To the President and Members of the Franklin Institute:

The Committee on Science and the Arts has the honor to submit the following account of its operations during the year 1906:

The total number of cases on the record book for 1906 was 61, of which 41 were carried over from last year, and 20 were new cases added in 1906.

The number of cases disposed of during 1906 was 22. In two cases the Elliott Cresson Medal was awarded; six received the award of the John Scott Legacy Premium and Medal; three received the Edward Longstreth Medal of Merit; and one received the Certificate of Merit. Three reports were made advisory and six were dismissed. There were two protested cases and one supplementary report.

Appended hereto is a list of the awards.

Respectfully submitted,

HUGO BILGRAM,
Chairman of Committee for 1906.

PHILADELPHIA, PA., January 2, 1907.

APPENDIX.

AWARD OF THE ELLIOTT CRESSON MEDAL.

2351. The American Paper Bottle Company, for their "Paper Milk Bottles."
2385. Mr. William J. Hammer, for his "Historic Collection of Incandescent Electric Lamps."

AWARD OF THE JOHN SCOTT LEGACY PREMIUM AND MEDAL.

2365. C. J. Reed, for his "Speed-Jack."
2375. W. C. Heraeus, for his "Fused-Quartz Mercury Lamp."
2379. Louis H. Walter and James Alfred Ewing, for their "Method of Detecting Electrical Oscillations."
2381. Alexander Crawford Chenoweth, for his "Concrete Pile."
2384. Max E. Schmidt, for his "Moving Platforms."
2394. J. P Tirrell, J. R. Reynolds and Frederick S. Palmer, for their "Monarch Engine-stop and Speed Limit System."

AWARD OF THE EDWARD LONGSTRETH MEDAL.

2371. C. B. Weidlog, for his "Friction Indicator."
2374. Dr. G. H. Meeker, for his "Improvements in Analytical Apparatus."
2380. Wilbur I. Follett, for his "Time-Stamp."

AWARD OF CERTIFICATE OF MERIT.

2361. J. H. Hallberg, for his "Alternating Current Electric System."

REPORTS MADE ADVISORY.

2376. Victor P. DeKnight, for his "Rapid Fire Guns."
2386. Dr. L. Reuter, for his "Process for Soaps and Turpentine Derivatives."
2358. Supplementary report on Colt's Pistols.

DISMISSED.

2105. Hausemann's Knitting Machine.
2117. Paxson & O'Neill's Knitting Machine.
2193. Earl's Physiological Apparatus.
2295. Hall's Aluminum Inventions.
2296. Matthew's Photometer.
2349. Bowditch's Cotton-Picking Machine.

There is one Elliott Cresson Medal pending on account of a protest.

REPORT OF THE COMMITTEE ON MEETINGS FOR THE YEAR 1906.

To the President and Members of the Franklin Institute:

The Committee on Meetings has, as heretofore, arranged the programs of the ten stated meetings of the year. Concerning the character of the communications presented, the Committee has no special comment to make save to state that a number of them were deemed of sufficient importance

to warrant publication in the *Journal.* Among the interesting events of the past year were the meetings held in commemoration of the 200th anniversary of the birth of Franklin.

The Committee has noted with regret the continued falling off in the attendance of members at the monthly meetings, a circumstance that has received notice in previous reports.

This is due, in part, to the fact that the Section meetings divert, to some extent, the interest of the members, but probably more largely to the inconvenient situation of the Hall. This circumstance is one of many that serves to accentuate the imperative need of providing a new building for the Institute in a more convenient locality.

Respectfully submitted,

WASHINGTON JONES,
Chairman of Committee on Meetings.

PHILADELPHIA, PA., January 2, 1907.

REPORT OF THE COMMITTEE ON PUBLICATION FOR THE YEAR 1906.

To the Board of Managers:

The Committee on Publication respectfully reports that the material offered for publication has fully met its necessities, in quality as well as quantity. The Board and members have reason for congratulation in the fact that the *Journal* of recent years has become what its name implies, the Journal of the Franklin Institute, the numerous contributions to its pages by the Sections, the meetings of the Institute and its several committees, evincing the continued activity of the Institute. The contract for printing the *Journal,* entered into last year, has been continued during 1906 and the Committee is pleased to announce that the promise of substantial saving in the cost of publication has been fully realized.

H. W. JAYNE,
Chairman of Committee on Publication.

PHILADELPHIA, PA., January 9, 1907.

REPORT OF THE COMMITTEE ON INSTRUCTION FOR THE YEAR 1906.

To the Board of Managers:

The School and lecture work has been carried on during the past year along the same lines as heretofore. Twelve popular lectures, all generously illustrated, were given under joint patronage of the Central Branch of the Young Men's Christian Association, and were largely attended. The lecturers as a rule proffered their services without compensation, and the thanks of the Board are due to these gentlemen for their services.

The Schools of Drawing, Machine Design and Naval Architecture have been well patronized, the attendance of pupils being as follows:

	1906
Drawing School	272
" " (Branch School)	197
School of Machine Design	114
School of Naval Architecture	15
Total	598

Considering the very indifferent accommodations offered to our pupils, when compared with those of other institutions engaged in similar work, the large attendance speaks well for the thoroughness of their instruction and the competency of the instructors.

Respectfully submitted,

WM. H. WAHL,
Chairman of Committee on Instruction.

PHILADELPHIA, PA., January 2, 1907.

REPORT OF THE COMMITTEE ON SECTIONAL ARRANGEMENTS FOR THE YEAR 1906.

To the Board of Managers:

Your Committee has pleasure in reporting that the various Sections have displayed a gratifying amount of activity during the past year. No less than twenty-six meetings were held.

Besides the large number of scientific and technical papers, several important technical subjects were discussed, and a number of papers were read by title because of the overcrowded state of the Sections' schedules.

The major portion of the pages of the *Journal* were, and for a number of years have been, devoted to the excellent material provided by the Section proceedings, and the value of these contributions has been shown in the most gratifying manner by their frequent reproduction in the scientific and technical journals, domestic and foreign.

The contributions of the Sections are to be credited as follows:—

Section of Physics and Chemistry	7
Electrical Section	5
Mining and Metallurgical Section	4
Mechanical and Engineering Section	5
Photographic and Microscopic Section	5
Total	26

The union of the Physical and the Chemical Sections has proved to be beneficial to both bodies.

In conclusion, your Committee wishes to express its appreciation of the substantial services of the professors, lecturers, and the Section officials, in assisting in providing material for the meetings.

Respectfully submitted,

JAMES CHRISTIE,
Chairman of Committee on Sectional Arrangements.

PHILADELPHIA, PA., January 2, 1907.

REPORT OF THE COMMITTEE ON ELECTION AND RESIGNATION OF MEMBERS FOR THE YEAR 1906.

To the Board of Managers:

GENTLEMEN:—The Committee on Election and Resignation of Members respectfully submits the appended figures for the year in relation to the membership.

The systematic efforts to obtain new members have been continued, and the Committee's work supplemented by that of a few of the members of the Institute has resulted in the placing of seventy new names on the list. This number has not been sufficient to overcome the loss through death, resignation and non-payment of dues, which amounts to ninety-two. The change in the numerical strength of the Institute is noted below in figures. The members of the Institute generally are urged to second the efforts of the Committee by nominating new members. One new member per year secured by each old member, would be easily possible of accomplishment.

The membership at the close of 1905 was	1554
New members secured in 1906	70
	1624
Loss by death, resignation and non-payment	92
Members at close of 1906	1532

Respectfully submitted,

ALEXANDER KRUMBHAAR,
Chairman.

PHILADELPHIA, PA., January 1, 1907.